

Chronic Pancreatitis - Definition, classification and cross-sectional imaging findings

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Learning objectives

The objectives of this educational exhibit are:

- To illustrate the imaging findings of chronic pancreatitis (CP), emphasizing two forms, namely groove pancreatitis and autoimmune pancreatitis.
- To highlight imaging features that may help in distinguishing between carcinoma and chronic pancreatitis.

Background

Chronic pancreatitis is a continuing (aseptic) inflammatory disease process characterized by irreversible damage of the pancreas resulting in progressive impairment of both endocrine and exocrine functions.

The incidence of CP ranges from 3.5 - 10.0 / 100000 people in industrialized countries. Multiple etiological factors have been implicated and lists of potential factors are represented on [Table 1](#) on page 5; alcohol abuse (70%) and gallstone biliary disease (20%) are considered the main etiologic factors.

Potential etiologic factors of chronic pancreatitis	
Toxic	Alcohol, cigarette smoking, drugs (e.g. glucocorticosteroids, azathioprine, hydrochlorothiazide, estrogens, valproic acid, phenacetin)
Metabolic	Hyperlipidemia, hypercalcemia, hyperparathyroidism, chronic renal failure
Infectious	Mumps, coxsackie virus infection, HIV, cryptosporidium
Obstruction of the main pancreatic duct	Gallstones, neoplasms (pancreatic/periampullary), post-traumatic scarring, Sphincter of Oddi dysfunction, pancreas divisum, pancreas annulare
Autoimmune	Immunoglobulin G4-related sclerosing disease
Genetic / hereditary	CFTR mutation (cystic fibrosis), PRSS1 mutation, SPINK1 mutation
Recurrent acute pancreatitis	Postnecrotic, recurrent acute pancreatitis
Other	Idiopathic, tropical pancreatitis, radiation therapy, vascular disease (polyarteritis nodosa, severe arteriosclerosis)

Table 1

References: Serviço de Imagiologia, Hospital S. Teotónio - Viseu/PT

The pathogenesis of CP has been subject to several theories:

- The *ductal theory*: ducts are the primary target of the disease, with stagnation of pancreatic juice, subsequent formation of protein plugs, with bile and duodenal juice reflux. The protein plugs undergo calcium carbonate calcification resulting in intraductal calculi leading to upstream dilatation and inducing periductal fibrosis.
- The *metabolite theory*: toxic metabolites induce proliferation of profibrotic cells and inflammatory response leading to periacinar fibrosis.
- The *necrosis-fibrosis theory*: chronic obstruction of the acini likely caused by stones leads to ulceration, scarring and chronic inflammatory response.
- The oxidative stress theory: Peroxidation of lipid membrane components of the acinar cells occurs due to excess free radicals leading to the inflammatory response.
- The multiple-cause theory: different and multiple causative factors damage the pancreatic parenchyma through distinct pathways.

Diagnosis of CP is based on:

- 1) Clinical symptoms (diabetes, steatorrhea, chronic recurrent abdominal pain);
- 2) Imaging findings;
- 3) Assessment of pancreatic function.

The correlation between these hallmarks is however poor, mainly because patients with severe exocrine insufficiency may present a structurally normal pancreatic parenchyma and vice-versa.

Imaging modalities

On abdominal radiographs calcifications over the epigastric region can be seen in 30-70% of patients with chronic pancreatitis, but they must be differentiated from calcified solid masses, calcified cysts and vascular calcifications.

Ultrasound evaluation of pancreas is also limited in patients with chronic pancreatitis and calcifications can be seen in up to 40% of patients, and may be focal or diffuse. Other findings such as atrophy, ductal dilatation and pseudocysts can also be observed.

Computed tomography (CT) is usually the first imaging method in assessing patients with CP, the main disadvantages of this method is the exposure of patients to radiation and the lack of functional evaluation component.

Magnetic resonance (MR) and MR cholangiopancreatography (MRCP) is becoming used more frequently to evaluate patients with CP. It's main advantages are the noninvasive biliary and pancreatic duct imaging, adequate characterization of the pancreatic parenchyma, and the depiction of peripancreatic pathologic conditions. Furthermore MR with intravenous administration of secretin may reveal ductal abnormalities otherwise not detected on MRCP and gives an indirect measure of the pancreatic exocrine function. In addition diffusion-weighted images have been shown to provide information regarding the exocrine function.

In [Table 2](#) on page 5 we represent the common CT and MR protocols used when evaluating patients with CP (data adapted from reference 2).

	Protocols	Indications
Computed tomography	<ul style="list-style-type: none"> • Unenhanced • Arterial phase • Parenchymal phase • Portal venous phase 	<ul style="list-style-type: none"> • Detection of calcifications • Arterial mapping for surgical planning, arterial complications of CP • Assessment of pancreatic parenchyma, detect hypovascular lesions, venous complications of CP, pseudocysts • Evaluation of pancreatic duct and vascular structures
MR	<ul style="list-style-type: none"> • Axial T2-weighted fat suppressed images • T1 FSE or GRE with fat suppression • Contrast-enhanced MR: T1-weighted 3D GRE • Diffusion-weighted imaging 	<ul style="list-style-type: none"> • Assessment of pancreatic, bile ducts and cystic lesions • Assessment of pancreatic masses or focal pancreatitis • Assessment of inflammatory process, neoplasm and vascular involvement • Estimation of exocrine functional capacity
MRCP	<ul style="list-style-type: none"> • Axial and coronal SSFSE T2-weighted images • 3D MRCP 	<ul style="list-style-type: none"> • Assess ductal abnormalities and filling defects
Secretin - MRCP	<ul style="list-style-type: none"> • Secretin IV administration 1mL/10 kg • Axial, oblique and coronal thick-slab SSFSE projections every 30 sec for 10-15 minutes 	<ul style="list-style-type: none"> • Better delineation of the main pancreatic duct • Improve detection of pancreatic duct variants • Increases accuracy in detecting main pancreatic duct strictures • Indirect assessment of pancreatic exocrine reserve

Table 2: Computed tomography and magnetic resonance protocols in the study of chronic pancreatitis - adapted from Perez-Johnston R, Sainani NI, Sahani DV (2012) Imaging of chronic pancreatitis (including groove and autoimmune pancreatitis). Radiol Clin North Am 50:447-466

References: Serviço de Imagiologia, Hospital S. Teotónio - Viseu/PT

Images for this section:

Potential etiologic factors of chronic pancreatitis	
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Obstruction of the main pancreatic duct	Gallstones, neoplasms (pancreatic/periampullary), post-traumatic scarring, Sphincter of Oddi dysfunction, pancreas divisum, pancreas annulare
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	Protocols	Indications
Computed tomography	<ul style="list-style-type: none"> Unenhanced Arterial phase Parenchymal phase Portal venous phase 	<ul style="list-style-type: none"> Detection of calcifications Arterial mapping for surgical planning, arterial complications of CP Assessment of pancreatic parenchyma, detect hypovascular lesions, venous complications of CP, pseudocysts Evaluation of pancreatic duct and vascular structures
MR	<ul style="list-style-type: none"> Axial T2-weighted fat suppressed images T1 FSE or GRE with fat suppression Contrast-enhanced MR: T1-weighted 3D GRE Diffusion-weighted imaging 	<ul style="list-style-type: none"> Assessment of pancreatic, bile ducts and cystic lesions Assessment of pancreatic masses or focal pancreatitis Assessment of inflammatory process, neoplasm and vascular involvement Estimation of exocrine functional capacity
MRCP	<ul style="list-style-type: none"> Axial and coronal SSFSE T2-weighted images 3D MRCP 	<ul style="list-style-type: none"> Assess ductal abnormalities and filling defects
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Findings and procedure details

CHRONIC PANCREATITIS

CT imaging findings of chronic pancreatitis [Fig. 1](#) on page 28:

- Duct dilatation (up to 68%)
 - Dilatation of the main pancreatic duct or side branches is the most common finding. The ductal contour may be smooth, beaded or irregular
- Parenchymal atrophy (54%)
 - However it must be referred that around 22% of patients with exocrine insufficiency might not show atrophy in CT
- Intraductal or scattered parenchymal calcifications (50%)
 - Parenchymal calcifications usually involve the head of the pancreas more frequently, they may vary in size and morphology (punctuate, stippled or coarse) and be scattered throughout the pancreas.
 - Intraductal stones are considered the most reliable sign of chronic pancreatitis.

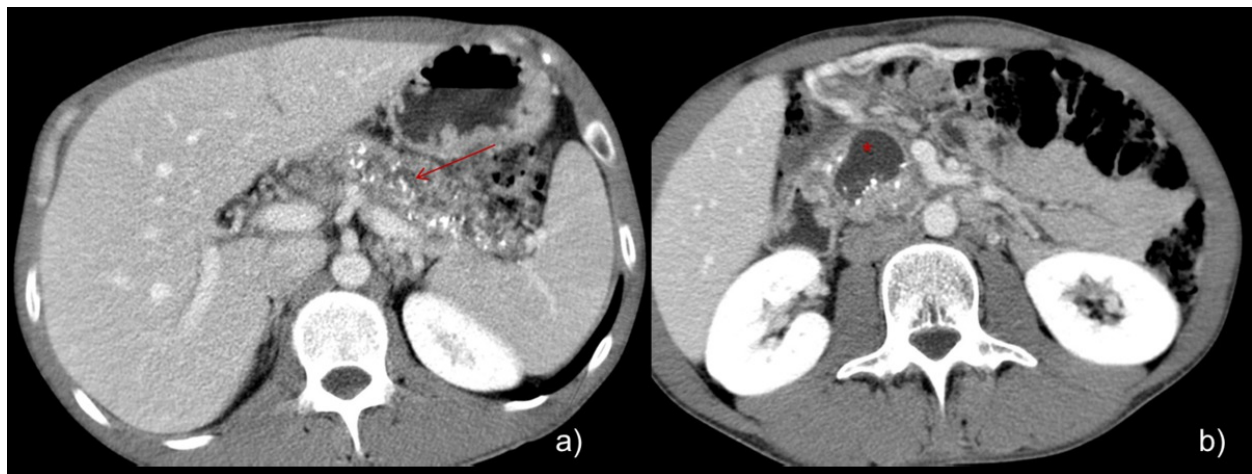


Fig. 1: a) e b) - Enhanced axial CT portal venous phase images showing irregular main pancreatic duct dilatation (arrow), with diffuse intraductal e parenchymatous calcifications. At the level head a pseudocyst is seen (*).

References: Medical Imaging Department and Faculty of Medicine, University Hospital of Coimbra, Portugal

CT imaging features of complications of chronic pancreatitis [Fig. 2](#) on page 29
[Fig. 3](#) on page 30 [Fig. 4](#) on page 30:

- Pseudocysts (detected in 25% of cases) [Fig. 2](#) on page 29
 - They consist in well-defined fluid density collections that may be localized within the pancreas, retroperitoneum or in distant locations
 - Usually they develop from peripancreatic fluid collections following a severe episode of acute pancreatitis. Sometimes there is no preceding history of acute pancreatitis, and pseudocysts develop from obstruction of the pancreatic duct or one of its side branches leading to a retention-type cyst upstream to the obstruction
- Venous thrombosis of the splenic, superior mesenteric or portal veins [Fig. 2](#) on page 29
 - Prevalence of splenic vein thrombosis in chronic pancreatitis is around 11%.
 - Collateral vessels are noted on CT images, and signs of sinistral or left-sided portal hypertension develop

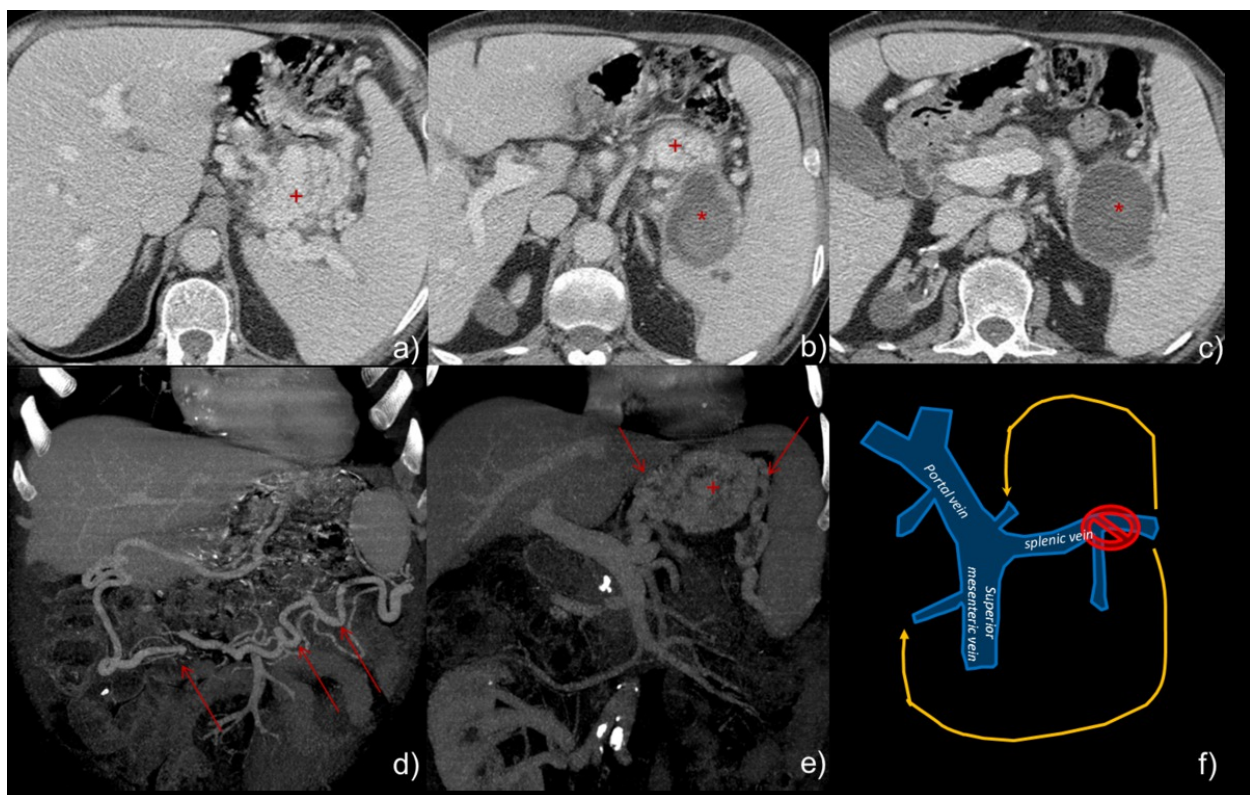


Fig. 2: Enhanced axial CT in portal venous phase images a), b) c) of a 63 year old patient with anaemia and previous renal transplantation demonstrating important signs of hypertensive gastropathy (+) with a haemorrhagic pseudocyst at the pancreas tail (*), splenomegaly with splenic vein occlusion and consequent collateralization by the gastroepiploic veins inferiorly and by short gastric and left gastric vein superiorly (arrows), better shown with the thick coronal MIP images in d) and e). In f) a schematic representation of left sided portal hypertension is shown, consisting in the presence

of digestive haemorrhage and splenomegaly with normal hepatic laboratorial values, usually due to splenic vein occlusion.

References: Medical Imaging Department and Faculty of Medicine, University Hospital of Coimbra, Portugal

- Pseudoaneurysms formation [Fig. 2](#) on page 29 [Fig. 3](#) on page 30
- They occur to the chronic inflammation and spillage into the retroperitoneum and adjacent arterial structures. Patients usually present with intense right upper quadrant/epigastric pain or gastrointestinal bleeding.
- They arise more frequently from the splenic artery, pancreaticoduodenal and gastroduodenal arteries, and less frequently from the middle colic artery. CT is important for adequate treatment

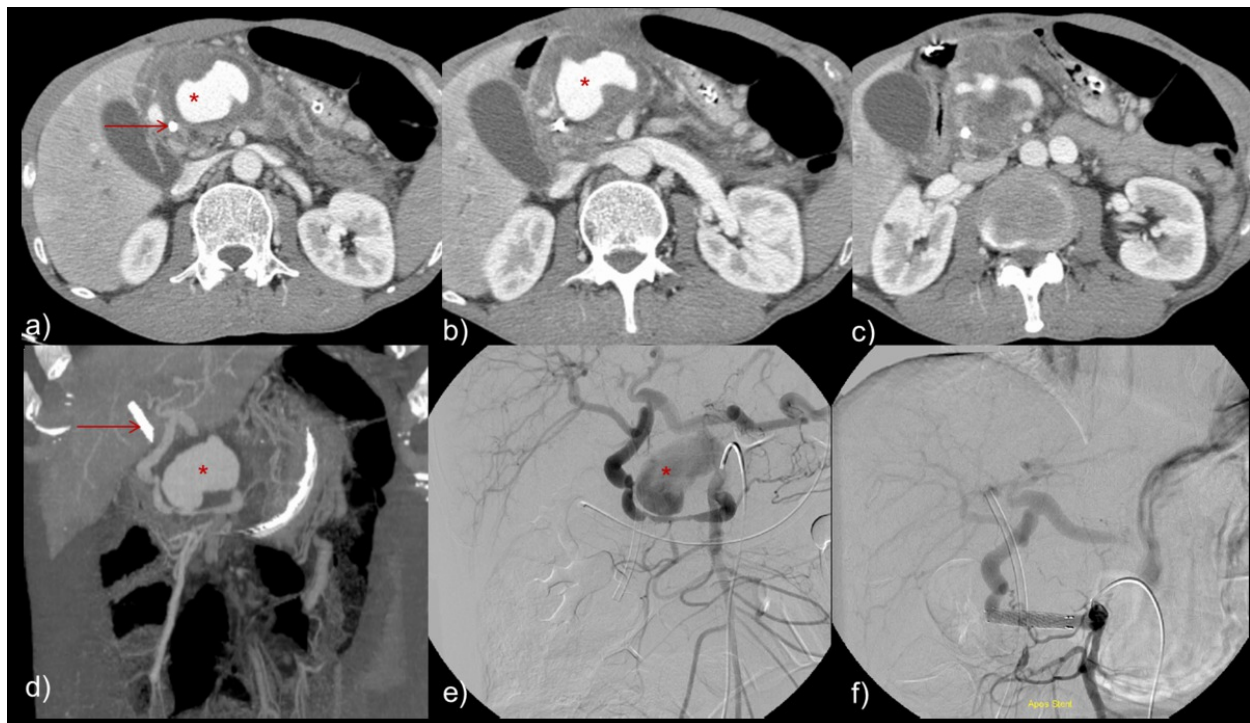


Fig. 3: Enhanced axial CT arterial phase images a), b) c) of a 53 year old male patient with severe chronic pancreatitis with a plastic biliary stent (arrows) and a large gastroduodenal pseudoaneurysm (*). Thick coronal MIP image d) demonstrated a narrow neck and a covered stent was deployed via the pancreatico-duodenal inferior artery with successful exclusion of the aneurysm e) and f).

References: Medical Imaging Department and Faculty of Medicine, University Hospital of Coimbra, Portugal

- Fistula formation [Fig. 4](#) on page 30
- It may reach the abdominal cavity leading to ascites or the pleural space leading to pancreatic pleural effusion. When sampled, both peritoneal and pleural fluids are rich in amylase.

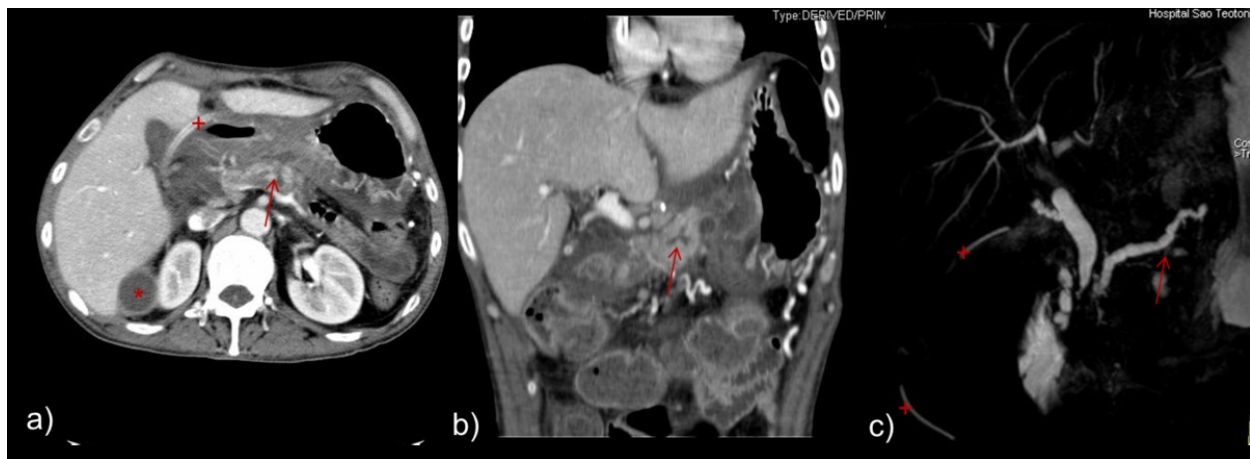


Fig. 4: axial and coronal enhanced CT images a) b) and coronal oblique MIP MRCP image c) of a patient with ascites and history of pancreatitis in whom a focal discontinuity of the main pancreatic duct was observed at the pancreatic body (arrows) corresponding to a fistula. In the image an external drain (+) a collection posterior to the right lobe of the liver (*) can be appreciated.

References: Serviço de Imagiologia, Hospital S. Teotónio - Viseu/PT

MR findings in chronic pancreatitis Fig. 5 on page 31 Fig. 6 on page 31 Fig. 7 on page 31 Fig. 8 on page 32

The appearance of CP on MR imaging is based on parenchymal morphological changes and ductal changes, and they can be divided in early or late findings.

- Parenchymal findings
 - Early stage:
 - Loss of normal hyperintense signal on T1-weighted images
 - Due to chronic inflammation and fibrosis leading to a decrease in the proteinaceous fluid within the parenchyma.
 - Decreased and heterogeneous early enhancement
 - Probably due to arteriolar damage and fibrosis
 - Delayed parenchymal enhancement
 - The most sensitive parameter for early diagnosis
 - Late stage:
 - Atrophy in addition to altered signal intensity and enhancement (Fig. 5 on page 31)

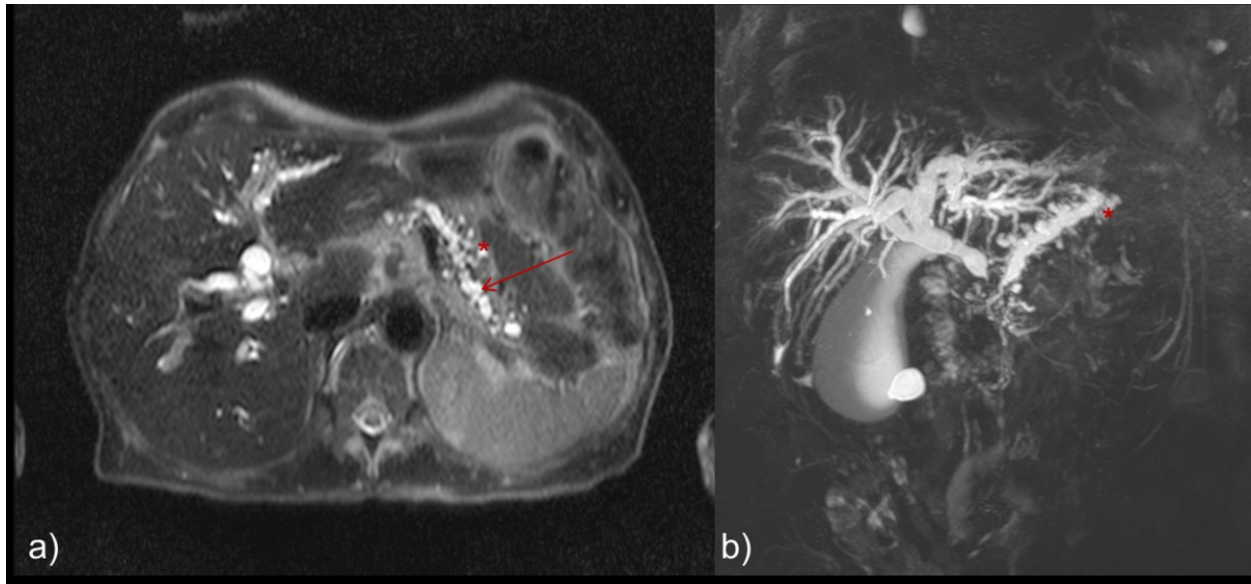


Fig. 5: Axial T2-weighted image FSE with fat saturation a) and coronal thick-slab MRCP image b), in a patient with severe chronic pancreatitis demonstrating irregular main pancreatic dilatation and dilatation of several side branch ducts (*), with parenchymal atrophy . Bile duct dilatation is also seen. This patient also had computed tomography examinations, whose findings were suggestive of chronic pancreatitis.

References: Medical Imaging Department and Faculty of Medicine, University Hospital of Coimbra, Portugal

- *Ductal changes*
 - Early stage:
 - Dilatation and irregularity of side branches.
- Late stage:
 - Dilatation and irregularity of the main pancreatic duct with strictures (Fig. 5 on page 31 Fig. 6 on page 31)
 - The beaded main pancreatic duct with its dilated side branches may have a chain-of-lakes appearance.
 - Intraductal calcifications (Fig. 6 on page 31)
 - Hypointense filling defects within the hyperintense fluid of the duct

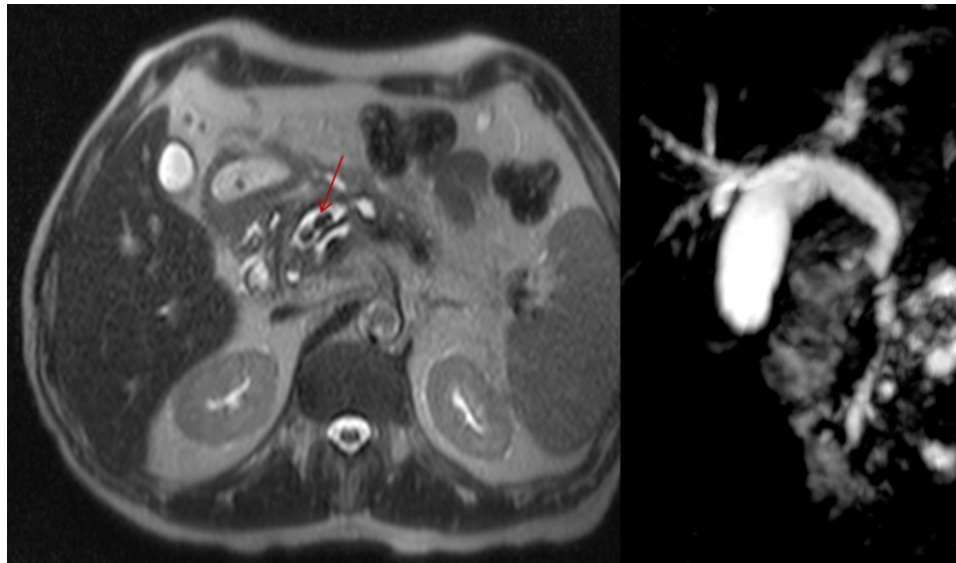


Fig. 6: Axial HASTE image a) and coronal oblique MIP MRCP image b) demonstrating irregular main pancreatic duct dilatation with two intraluminal calcifications (arrows).

References: Medical Imaging Department and Faculty of Medicine, University Hospital of Coimbra, Portugal

- Pseudocysts ([Fig. 7](#) on page 31)

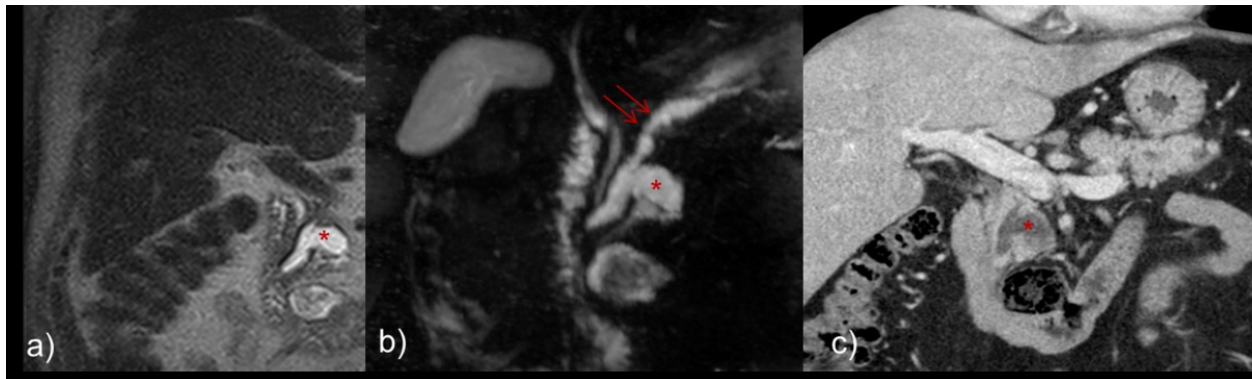


Fig. 7: Coronal HASTE image a), coronal thick MRCP projection b) and enhanced coronal CT portal venous phase image c) of a patient with main pancreatic duct strictures and irregular dilatation with a pseudocyst in the pancreatic head communicating with the main pancreatic duct.

References: Medical Imaging Department and Faculty of Medicine, University Hospital of Coimbra, Portugal

MR Cholangiopancreatography and secretin-MRCP role in chronic pancreatitis:

MRCP is highly accurate in diagnosing anatomic variants, such as pancreas divisum ([Fig. 8](#) on page 32), that may be associated with CP.

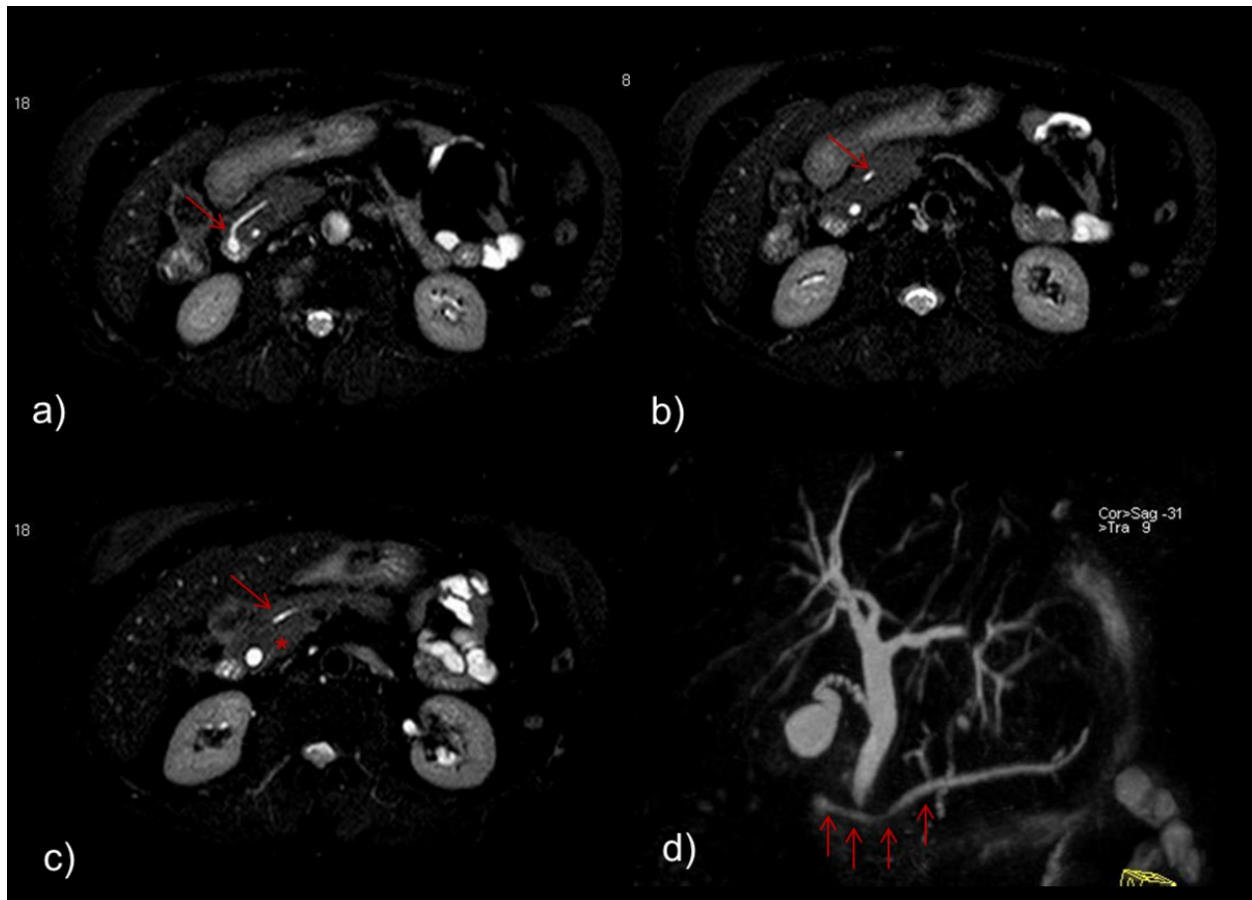


Fig. 8: Axial T2 FSE fat-suppression images a) b) c) and coronal oblique MIP MRCP image d) demonstrating the main pancreatic duct is in continuity with the duct of Santorini emptying through the minor papilla to the duodenum (arrow). Also a small ventral duct is seen in image c) (*).

References: Serviço de Imagiologia, Hospital S. Teotónio - Viseu/PT

In early states of chronic pancreatitis MRCP is slightly less sensitive in visualizing the dilatation and irregularity of the side branches ducts that are better visualized by endoscopic retrograde cholangiopancreatography (ERCP).

In this sense, patients with abnormal parenchymal MR imaging findings but normal MRCP may benefit from secretin-MRCP that may reveal abnormalities not detected in MRCP. In normal subjects within 2-6 minutes of secretin injection, a progressive dilatation of the main pancreatic duct is observed, with a peak 2-3 minutes after secretin injection; then the caliber of the main pancreatic duct returns to baseline value within 10 minutes, as pancreatic juice flows out through the papilla and progressively fills the duodenum.

Impaired response of the pancreatic ducts at s-MRCP includes:

- Prolonged dilatation of the whole main pancreatic duct (> 3 mm at 10 min) with delayed recovery of the baseline diameter in patients younger than 60 years of age.
 - In patients with chronic pancreatitis the baseline diameters of the main pancreatic duct are larger than the control population, and in the dynamic assessment the time to reach the peak diameter is longer and the percentage of increase in the diameter is low.
- Visualization of prolonged dilatation of side branches and the potential occurrence of progressive increase in the signal intensity of the pancreas parenchyma, mimicking a parenchymography.
- Reduced duodenal filling (limited to the duodenal bulb) 10 minutes after secretin administration.

Added value of diffusion weighted imaging

ADC values are lower in patients with CP when compared with normal subjects:

- This occurs probably due to replacement of normal parenchyma by fibrous tissue which may reduce the amount of diffusible tissue water
- After secretin administration ADC values increase from baseline, in contrary in patients with chronic pancreatitis no oscillation of ADC values are observed.

Differential diagnosis with ductal adenocarcinoma

Pancreatic cancer is the most crucial complication in patients with chronic pancreatitis; furthermore sometimes chronic pancreatitis can cause a focal enlargement of the gland leading to a common set of findings.

- Common findings [Fig. 9](#) on page 32:
 - Hypointense signal in T1-weighted images;
 - Low ADC values at diffusion weighted MRI
 - Late enhancement;
 - Dilatation of pancreatic and biliary ducts

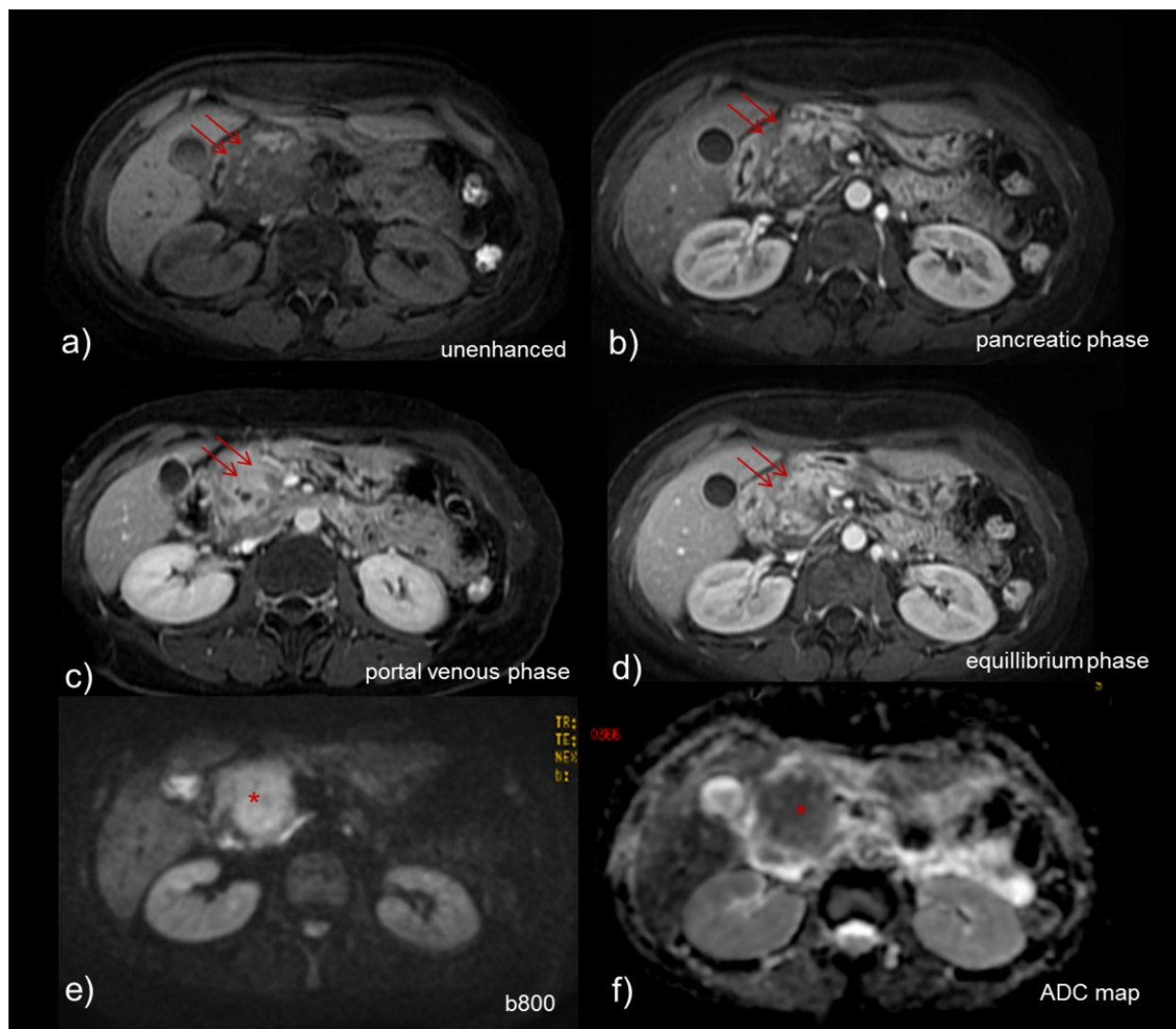


Fig. 9: Axial T1 3D fat-saturation images a) b) c) d) , axial DWI b-800 image e), ADC map f) of a patient with a hypointense mass at the pancreatic head (arrows), enhancing only in portal venous phase favoring inflammatory origin (usually adenocarcinomas enhance typically in more late phases). The lesion demonstrated restricted diffusion with low ADC values (*), however diffusion-weighted imaging doesn't allow differentiation between malignant and inflammatory masses.

References: Medical Imaging Department and Faculty of Medicine, University Hospital of Coimbra, Portugal

- Findings suggesting chronic pancreatitis [Fig. 10](#) on page 33 [Fig. 11](#) on page 35 [Fig. 12](#) on page 35:
 - Visualization of the main pancreatic duct penetrating the mass with regular stenosis - "penetrating duct sign"
 - The ductal dilatation is less severe and more irregular, with multiple ductal strictures and dilatation of side branches
 - Intraductal or scattered parenchymal calcifications;
 - Absence of clear demarcation between the focal mass and the parenchyma;

- Diffuse pancreatic involvement

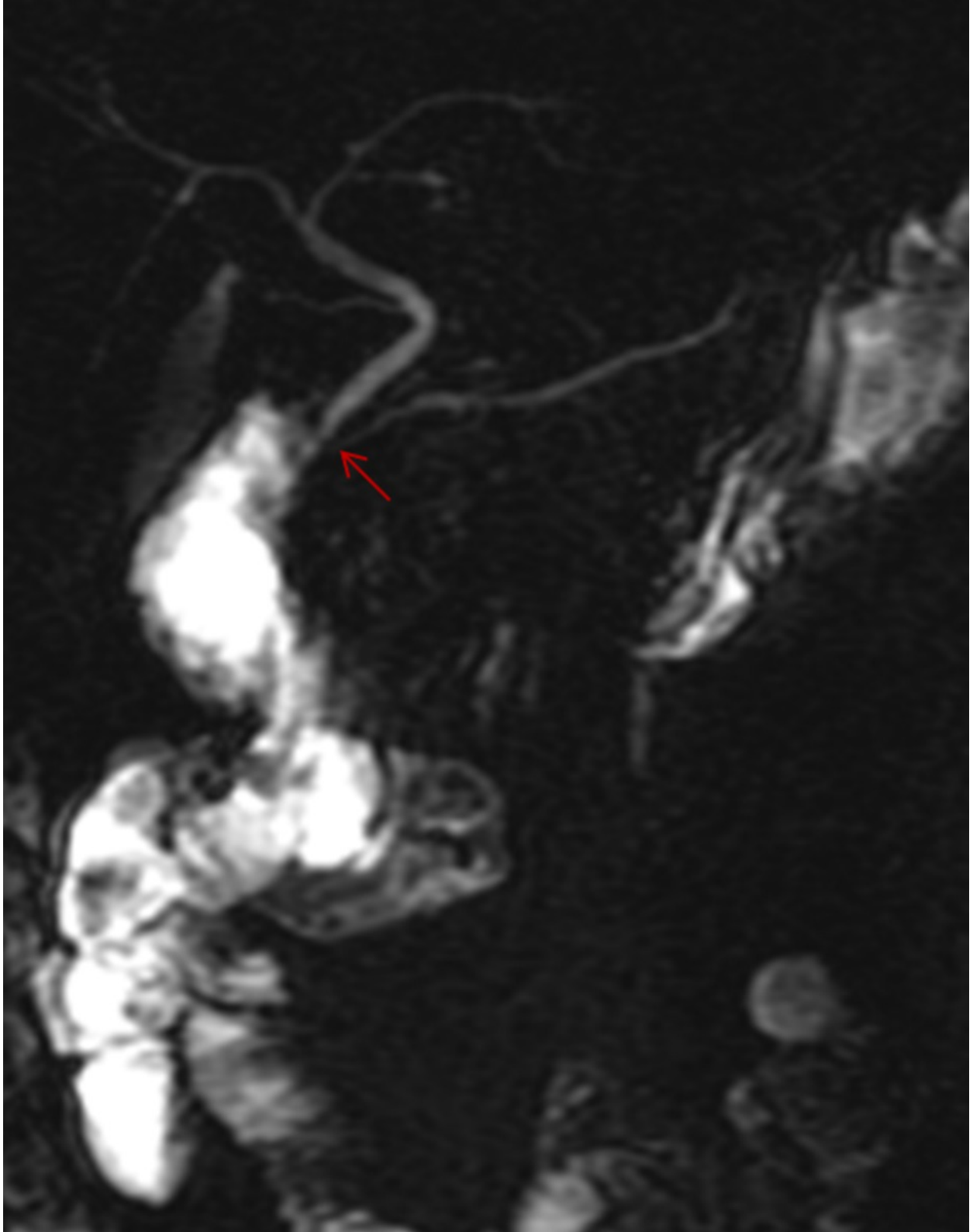


Fig. 10: Coronal oblique thick slab MRCP projection of the same patient in figure 8, disclosing regular narrowing of the main pancreatic duct at the pancreatic head - duct penetrating sign (arrow) - finding that suggest inflammatory origin. This patient performed endoscopy ultrasound with biopsy and the results confirmed focal pancreatitis.

References: Medical Imaging Department and Faculty of Medicine, University Hospital of Coimbra, Portugal

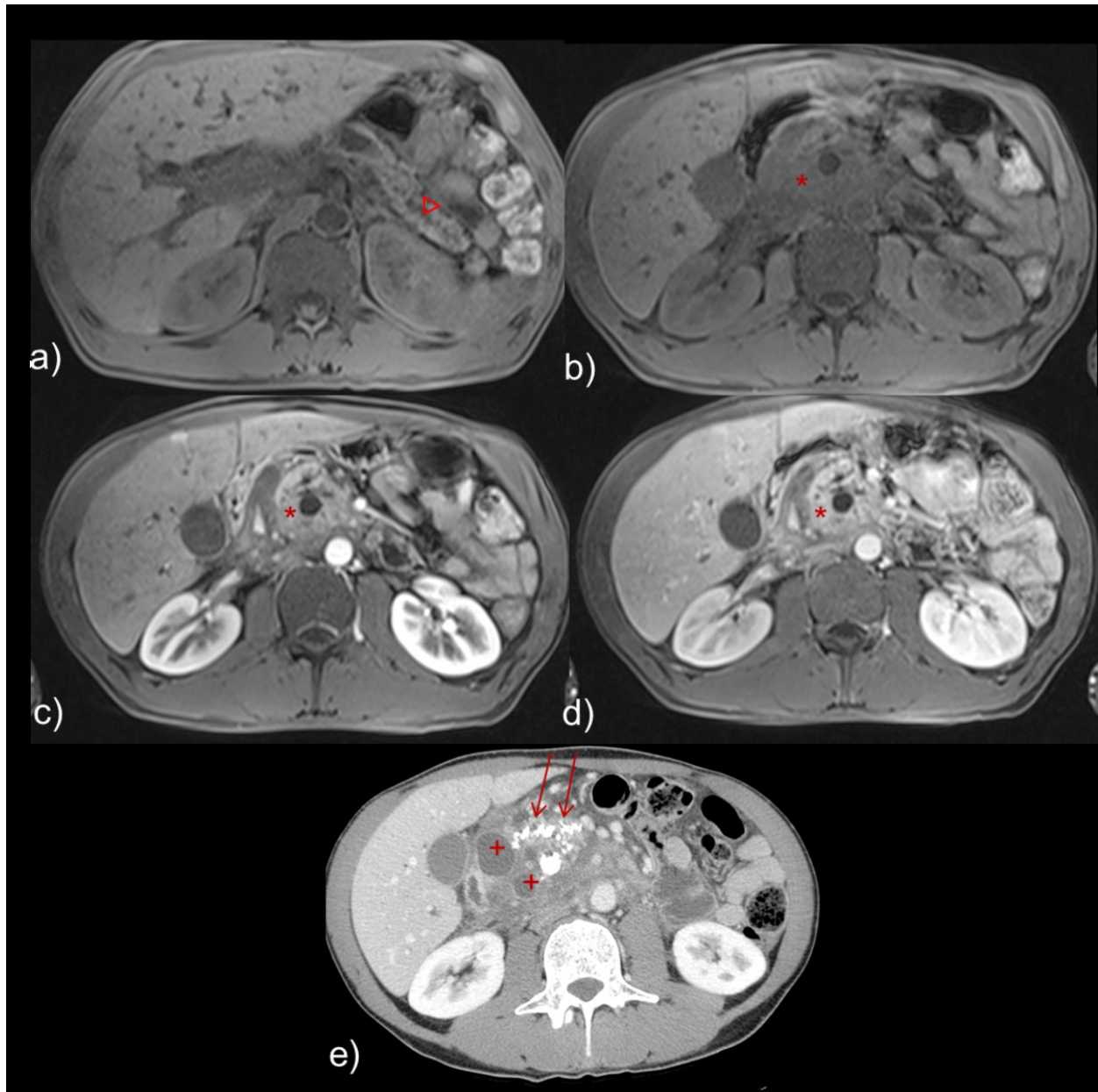


Fig. 11: Axial T1 3D fat saturation non-enhanced images a) b), axial T1 3D fat saturation enhanced images c) d), enhanced axial CT image in portal venous phase e) - Another patient with an irregular main pancreatic duct dilatation (arrowhead) and a hypointense mass at the pancreatic head and isthmus (*), enhancing progressively,

also diffusion weighted imaging disclosed restricted diffusion with low ADC (not shown). At CT examination the patient presented several parenchymal and intraductal pancreatic calcifications (arrow) and also pseudocysts (+), findings favoring chronic pancreatitis.

References: Medical Imaging Department and Faculty of Medicine, University Hospital of Coimbra, Portugal

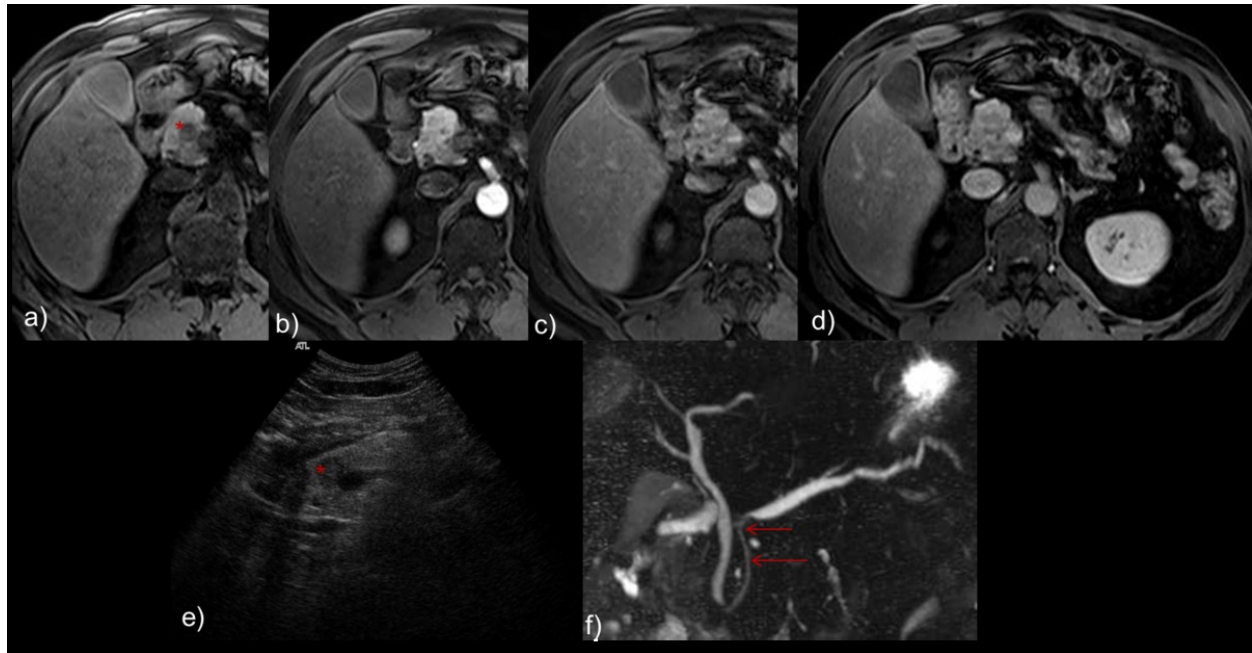


Fig. 12: Axial T1 3D fat-saturation images a) b) c) d), transversal ultrasound image e), coronal oblique thick slab MRCP image f) - Patient with a hypoechogenic pericentimetric nodule at the pancreatic head. This nodule was not observed at CT and in MR the nodule was hypointense in T1 enhancing similarly to the remaining pancreatic head, with absence of clear demarcation between the focal nodule and the parenchyma. DWI (not shown) demonstrated restricted diffusion. At MRCP a regular and smooth narrowing of the main pancreatic duct at the pancreatic duct - duct penetrating sign (arrows) is seen suggesting the diagnosis of focal pancreatitis.

References: Medical Imaging Department and Faculty of Medicine, University Hospital of Coimbra, Portugal

- Findings suggesting adenocarcinoma [Fig. 13](#) on page 36 [Fig. 14](#) on page 37:
- - Vascular invasion;
 - Fewer ductal calculi;
 - Larger caliber and more regular pancreatic duct dilatation with abrupt cutoff in the mass without the penetrating duct sign;
 - Main pancreatic duct dilatation without side branch dilatation associated with common bile duct dilatation with abrupt cutoff - "double duct sign".

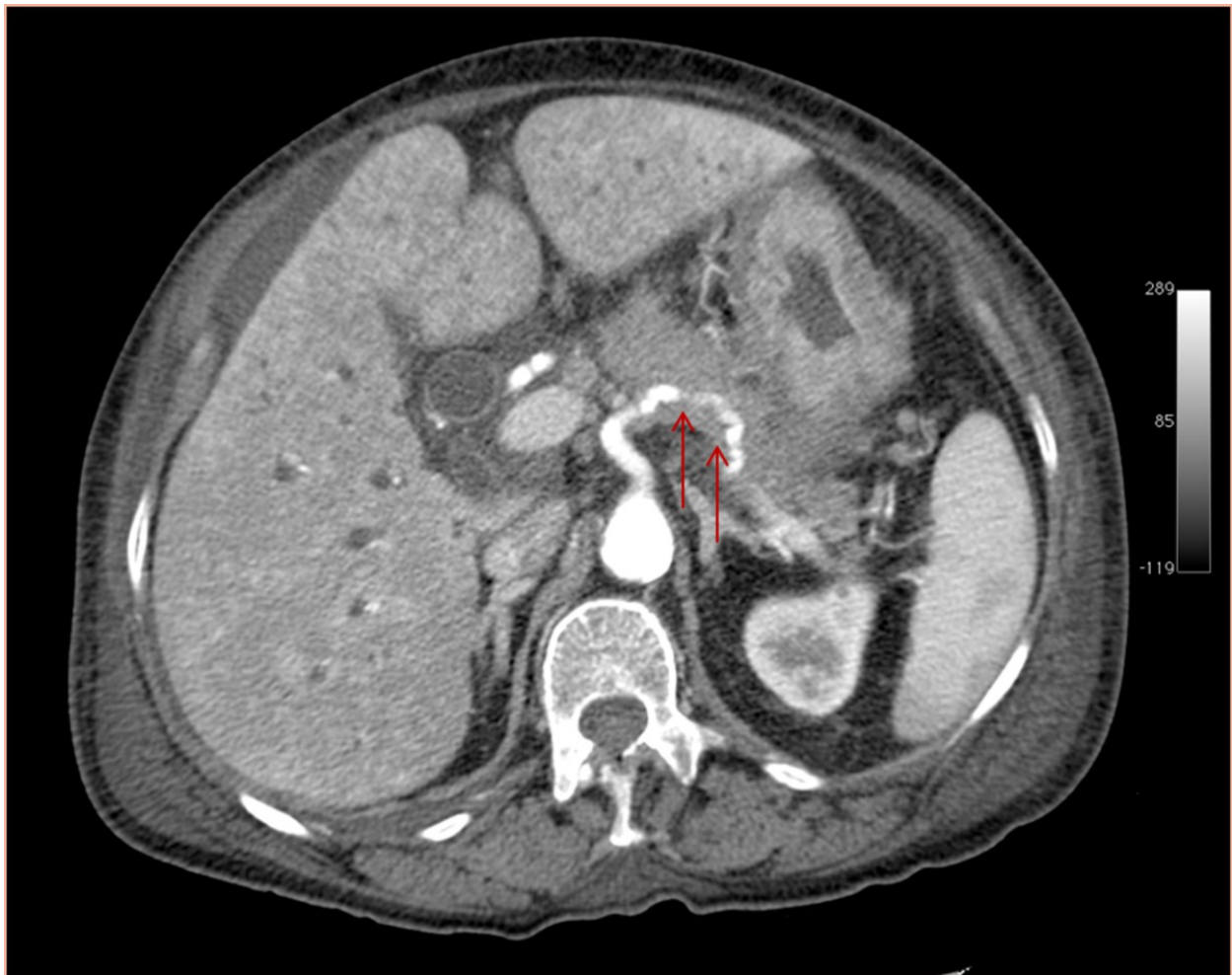


Fig. 13: Enhanced axial CT image in pancreatic phase of a patient with a hypodense mass in pancreatic body, with pancreatic tail atrophy and signs of vascular encasement of the splenic artery (arrows).

References: Serviço de Imagiologia, Hospital S. Teotónio - Viseu/PT

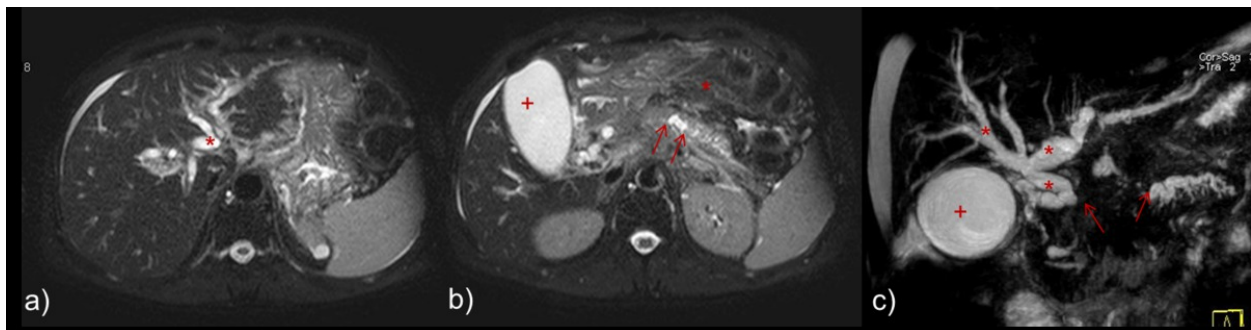


Fig. 14: Axial T2 FSE with fat suppression images a) b) and coronal oblique MIP MRCP image of a patient with bile duct dilatation (*), a distended gallbladder (+) as well as main pancreatic duct dilatation, an abrupt "cut-off" (arrows) at the pancreatic body

with distal pancreatic parenchymal atrophy. Further investigation revealed pancreatic adenocarcinoma. Perihepatic ascites is also seen in this image.

References: Serviço de Imagiologia, Hospital S. Teotónio - Viseu/PT

When cross-sectional imaging and biopsy are nondiagnostic, 18 FDG-PET has an established role in the diagnosis of pancreatic adenocarcinoma, especially in the setting of chronic pancreatitis; if acute pancreatitis is present, specificity can be low as 50%. A summary of differential criteria between CP and pancreatic adenocarcinoma is represented in [Table 3](#) on page 41.

	Chronic pancreatitis	Pancreatic adenocarcinoma
History	+++	-
Duct contour	Irregular	Smooth
Duct/parenchyma	<0.5	>0.5
Calcification	+++	-
Enhancement	Diffusely decreased / preserved	Focal decrease
Cysts	+++	+ (if cystic degeneration)
Lymph nodes	+	++ (suspicious)
Metastases	-	++++

Table 3: differential criteria between CP and pancreatic adenocarcinoma - table from Helmberger TK (2011) Pancreas - parenchymal disease. In: Gourtsoyannis NC, (ed) Clinical MRI of the abdomen. Springer, Berlin, pp 225-255

References: Serviço de Imagiologia, Hospital S. Teotónio - Viseu/PT

Differential diagnosis with intraductal papillary mucinous neoplasms (IPMN)

- Common findings [Fig. 15](#) on page 38:
 - Ductal dilatation that may be associated with parenchymal atrophy;
 - Side-branch IPMN present sometimes with cystic lesions often confused with pseudocysts

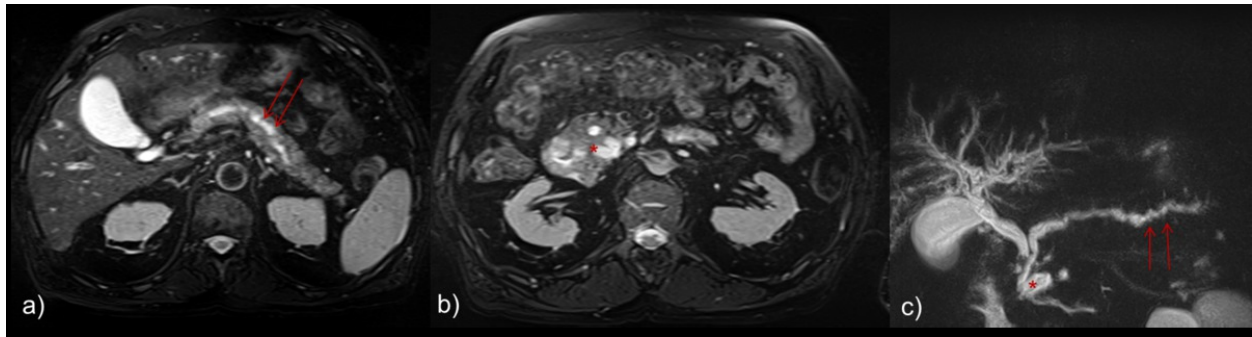


Fig. 15: Axial T2 FSE fat saturation images a) b) and coronal oblique thick MRCP image c) of an 81 year-old patient with irregular main pancreatic duct dilatation (arrows) with slight pancreatic parenchymal atrophy, presenting a cystic lesion at the pancreatic head communicating with the main pancreatic duct. This patient also presented stones at the distal main biliary duct.

References: Serviço de Imagiologia, Hospital S. Teotónio - Viseu/PT

- Findings suggesting IPMN [Fig. 16](#) on page 38:
 - Solid component within the main duct
 - Complex features (pseudoseptations, nodules) within the cysts.



Fig. 16: Axial a), coronal b) and sagittal c) enhanced images of a patient presenting with a complex cystic masse with pseudoseptations and subtle enhancing solid component (arrows). Pathological analysis confirmed the IPMN nature.

References: Serviço de Imagiologia, Hospital S. Teotónio - Viseu/PT

Endoscopic ultrasound with fine-needle aspiration may confirm the diagnosis of IPMN by demonstrating mucin in the fluid.

AUTOIMMUNE PANCREATITIS

Formerly described as "lymphoplasmocytic sclerosing pancreatitis" is a manifestation of an immunoglobulin G4 (IgG4) systemic disease and is a rare form of non-obstructive and noncalcifying chronic pancreatitis associated with an autoimmune inflammatory process. An association with other autoimmune disease as Sjogren syndrome, primary biliary cirrhosis, primary sclerosing cholangitis, Crohn disease, systemic LE, and retroperitoneal fibrosis is found in a third of cases.

Clinical presentation is varied, so as the age of presentation ranging from 14 to 85 years, with a mean of 60 years. Clinically and histologically AIP can be classified as:

- Predominant lobular involvement (*AIP-PL or type 1*) - predominant lobular inflammation, is a systemic disease, presents with higher number of IgG4 positive cells and is most commonly seen in Asian and males.
- Predominant ductal involvement (*AIP-PD or type 2*) - characterized by granulocyte epithelial lesions in the pancreas without systemic involvement, presenting commonly as a pseudotumor and is seen in the Western population

Patterns of AIP:

- Diffuse (most common)
 - The most common, presenting with sausage like parenchymal enlargement seen in 40% to 60% of patients.
 - The pancreatic contour becomes featureless and effaced
- Focal (less common)
 - Well-defined mass often involving the pancreatic head and mimicking pancreatic adenocarcinoma. Upstream dilatation may be seen, however it is less severe.

By itself, imaging findings are non-diagnostic; in [Table 4](#) on page 41 we represent the diagnostic criteria for AIP by the Japanese Pancreas Society.

1) Typical imaging	Diffuse or segmental narrowing of the pancreatic duct with irregular wall and diffuse or localized enlargement of pancreas on US, CT and MR imaging
2) Serology	Autoantibodies (antinuclear antibodies and rheumatoid factor), elevated γ -globulins, or IgG or IgG4
3) Histopathology	Marked intralobular fibrosis and prominent infiltration of lymphocytes and plasma cells in the periductal area, occasionally with lymphoid follicles in the pancreas
Diagnosis is established when criteria 1 with criteria 2 or 3 are present	

Table 4: Table 4 - Japanese society of pancreas criteria for autoimmune pancreatitis

References: Serviço de Imagiologia, Hospital S. Teotónio - Viseu/PT

CT Imaging findings in Autoimmune pancreatitis [Fig. 17 on page 38](#) [Fig. 19 on page 39](#)

- Usually diffuse sausage-like enlargement of pancreas, can be focal swelling, with loss of fatty lobulation;
- Enhancement is variable, often less enhancement than expected in arterial phase;
- Diffuse or segmental narrowing of pancreatic duct;
- Strictures of common bile duct and +/- intrahepatic ducts (indistinguishable from primary sclerosing cholangitis);
- Low-attenuation halo surrounding pancreas.

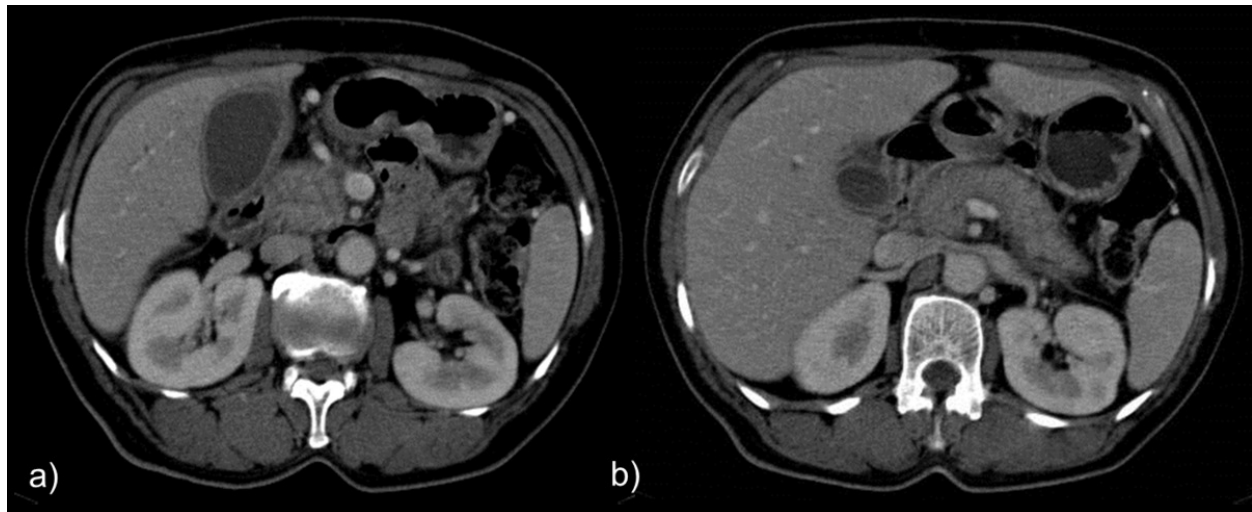


Fig. 17: Enhanced axial CT images in portal venous phase of a patient with slight diffuse enlargement of pancreas, with diffuse less enhancement and loss of normal fatty lobulation. A slight atrophy of the pancreatic tail can be seen as well as a low-attenuation halo surrounding pancreas.

References: Medical Imaging Department and Faculty of Medicine, University Hospital of Coimbra, Portugal

MR and MRCP imaging findings in autoimmune pancreatitis [Fig. 18 on page 39](#)

- Diffuse enlargement with low signal on T1-weighted images
- "Halo" of low signal on T2-weighted images and delayed enhancement
- - This capsule-like rim is hypointense on both T1- and T2-weighted images, is present in about 12% to 40% of patients and is thought to represent an inflammatory cell infiltration
 - Diffuse or segmental narrowing and irregularity of the main pancreatic duct
 - Stenosis, irregularity and increased enhancement of the bile ducts

- Sclerosing cholangitis is present in up to 88% of patients, the most common segment involved is the main pancreatic common bile duct, less frequently do the intrahepatic biliary strictures occur.



Fig. 18: Axial T2 weighted images of a patient with autoimmune pancreatitis demonstrating diffuse enlargement "sausage-like" of the pancreas (*) with a halo of low signal (arrows).

References: Medical Imaging Department and Faculty of Medicine, University Hospital of Coimbra, Portugal

Differential diagnosis with ductal adenocarcinoma

- Findings suggesting autoimmune pancreatitis [Fig. 19](#) on page 39 [Fig. 20](#) on page 40
- - Lack of upstream pancreatic ductal dilatation;
 - Absence of parenchymal atrophy, vascular encasement and metastasis;
 - Extrapancreatic diffuse changes related with IgG4 systemic disease;
 - Usually has good response to steroid therapy

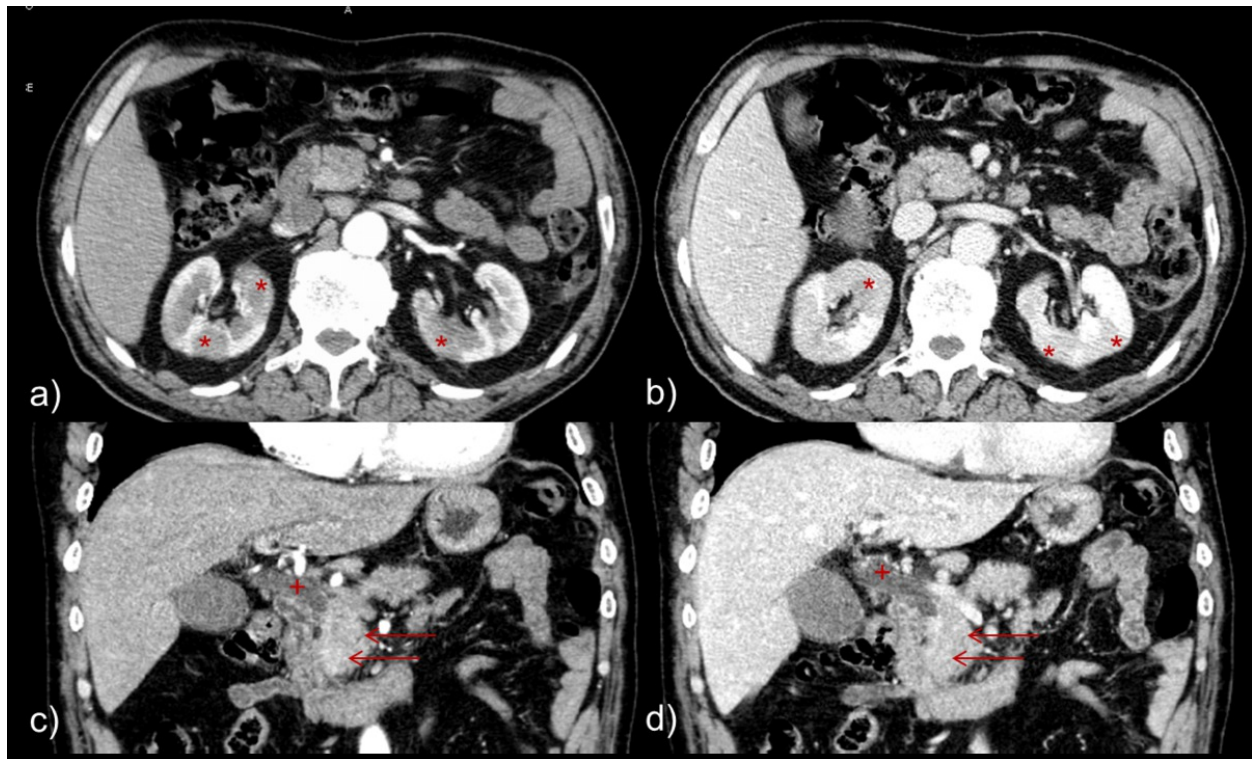


Fig. 19: Enhanced axial CT images in pancreatic a) and portal venous phase b), and enhanced coronal CT images in pancreatic c) and portal venous phase d) of a patient with a focal swelling at the pancreatic head, enhancing similarly with the remaining pancreatic parenchyma (arrows). This focal swelling was responsible for slight dilatation of the common bile duct (+), pancreatic parenchymal atrophy or main pancreatic duct dilatation was not seen. The presence of peripheral and wedge-shaped renal cortical nodules that were hypovascular in pancreatic phase with slight enhancement in portal venous phase (*) were consistent with interstitial nephritis, thus favoring the diagnosis of focal autoimmune pancreatitis. About 1/3 of the patients with autoimmune pancreatitis present interstitial nephritis also occurs.

References: Medical Imaging Department and Faculty of Medicine, University Hospital of Coimbra, Portugal

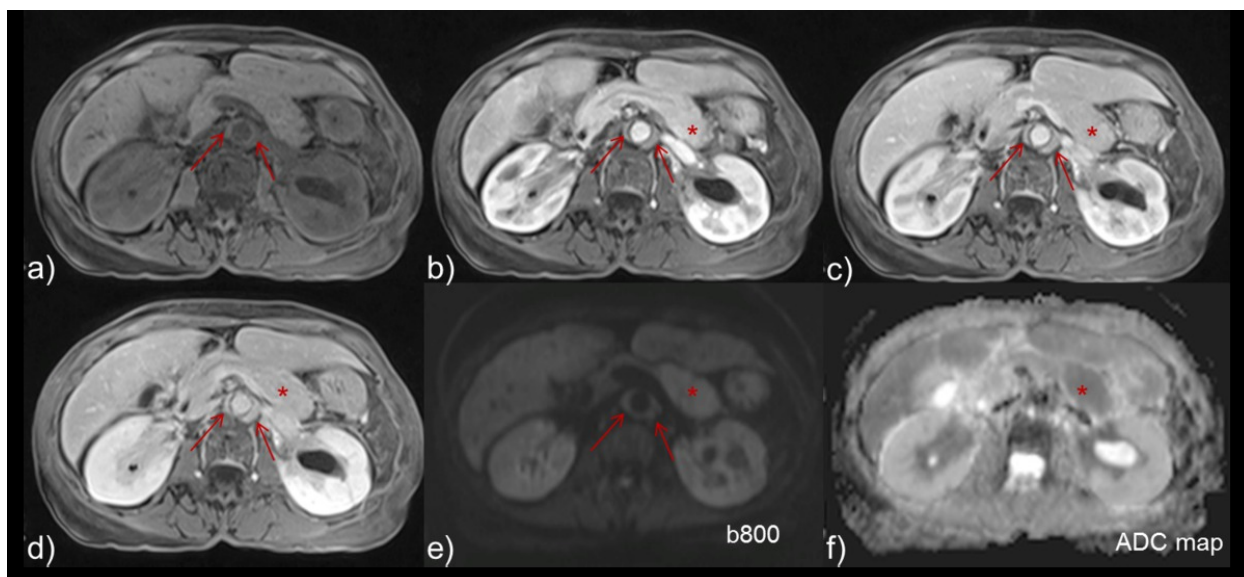


Fig. 20: Axial T1 3D fat-saturation images a) b) c) d) axial DWI b-800 image e) and ADC map f) of a patient with focal enlargement in the pancreatic tail that was isointense and enhancing similarly with the remaining parenchyma, presenting with restricted diffusion and low ADC (*). A soft tissue lesion around the aorta was also seen with similar features to the pancreatic lesion (arrows); furthermore the left kidney presented dilatation of the cavities, and the soft-tissue lesion corresponded to retroperitoneal fibrosis, seen in about 10-20% of patients with autoimmune pancreatitis. **References:** Medical Imaging Department and Faculty of Medicine, University Hospital of Coimbra, Portugal

PARADUODENAL PANCREATITIS (Groove Pancreatitis)

Groove pancreatitis is an uncommon form of chronic pancreatitis occurring predominantly in and around the duodenal wall near the minor papilla, being increasingly more diagnosed. Nowadays groove pancreatitis is included in the term paraduodenal pancreatitis, which also includes cystic dystrophy of the duodenal wall and paraduodenal wall cysts, which in fact reflect the different aspects of microscopic pathology.

There are three patterns of groove pancreatitis: pure (the head of the pancreas is spared), segmental (the pancreatic head and the ducts are affected), and nonsegmental (secondary to established chronic pancreatitis).

CT imaging findings in groove pancreatitis Fig. 21 on page 40 Fig. 22 on page 41 Fig. 23 on page 41

- Ill-defined soft-tissue within the pancreaticoduodenal groove, with or without delayed enhancement
- Duodenal wall thickening, with or without luminal stenosis
- Cystic changes of the duodenal wall

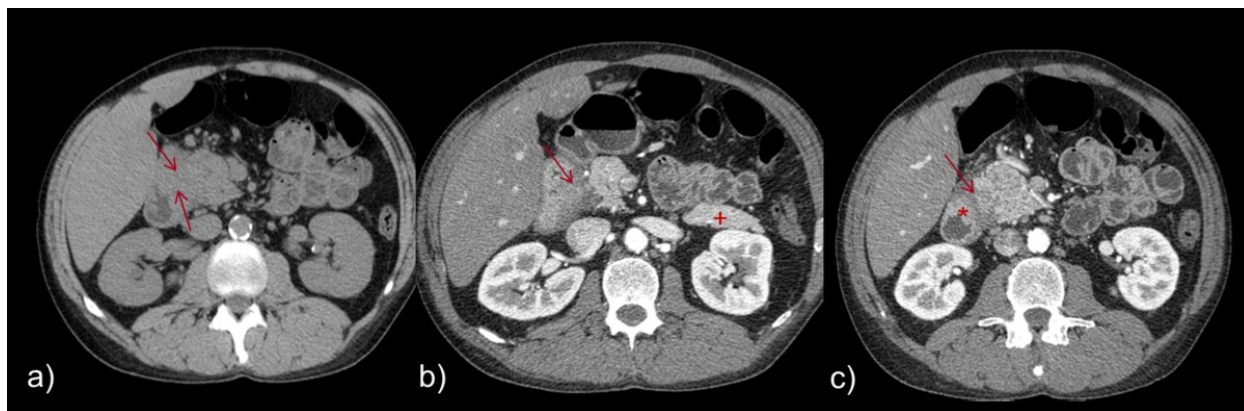


Fig. 21: Unenhanced a) and enhanced axial CT images b) c) of a patient presenting with an ill-defined "sheet-like" soft-tissue mass within the pancreaticoduodenal groove, hypointense to the pancreatic parenchyma after iodinated contrast medium administration (arrows). There is not parenchymal atrophy or main pancreatic duct dilatation (+) and thickening of the duodenal wall can be observed (*).

References: Medical Imaging Department and Faculty of Medicine, University Hospital of Coimbra, Portugal

MR imaging findings in Groove Pancreatitis [Fig. 22 on page 41](#)

- On T1-weighted images the groove is hypointense relative to rest of pancreas
- Pancreatic head may be enlarged and the remainder of pancreas may be atrophic
- On T2-weighted images the groove is isointense or slightly hyperintense relative to the pancreas.
- - Duodenal thickening and small cysts in the groove or medial wall of duodenum may appear
 - Long, smooth narrowing of intra-pancreatic common bile duct and distal main pancreatic duct
 - May show delayed enhancement

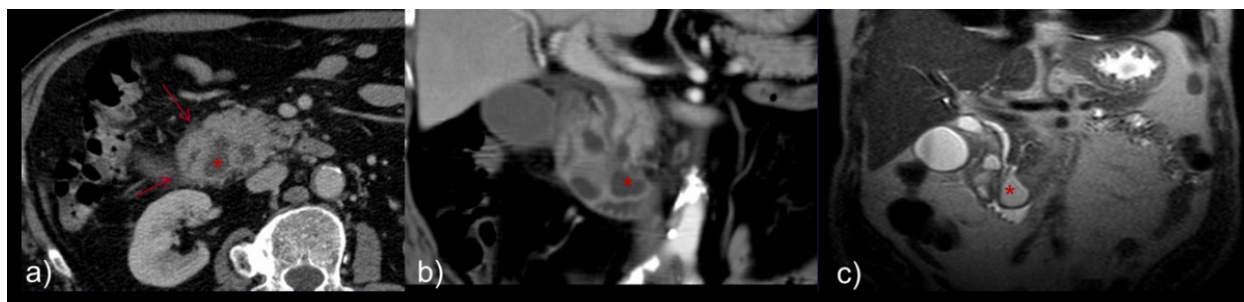


Fig. 22: Axial a), coronal b) enhanced CT images and coronal HASTE image c) of a patient with groove pancreatitis presenting with slight duodenal wall thickening (arrows) with discrete luminal stenosis and cystic changes of the duodenal wall (*).
References: Medical Imaging Department and Faculty of Medicine, University Hospital of Coimbra, Portugal

Differential diagnosis with ductal adenocarcinoma

- **Findings suggesting Groove Pancreatitis** [Fig. 23 on page 41](#)
- - The presence of cysts within the lesion and thickening of duodenal wall
 - Smooth and long narrowing of the main pancreatic duct
 - Absence of vascular invasion



Fig. 23: Enhanced axial a), coronal b) and thick-slab MRCP image c) of a patient with groove pancreatitis presenting a large hypodense mass at the pancreatic head with cystic areas (*) without vascular invasion and with smooth narrowing of the distal common bile and main pancreatic duct (arrow).

References: Medical Imaging Department and Faculty of Medicine, University Hospital of Coimbra, Portugal

Images for this section:

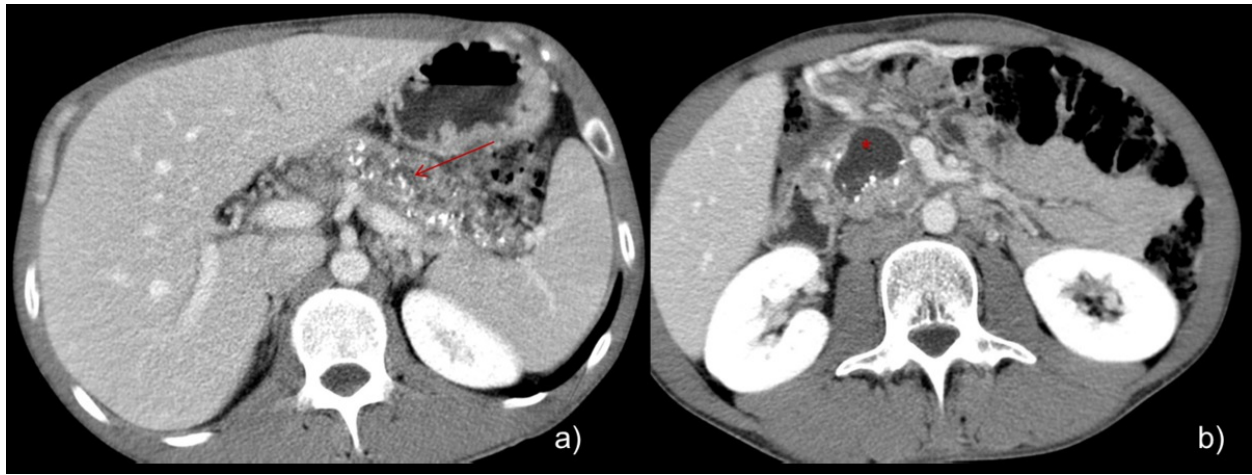


Fig. 1: a) e b) - Enhanced axial CT portal venous phase images showing irregular main pancreatic duct dilatation (arrow), with diffuse intraductal e parenchymatous calcifications. At the level head a pseudocyst is seen (*).

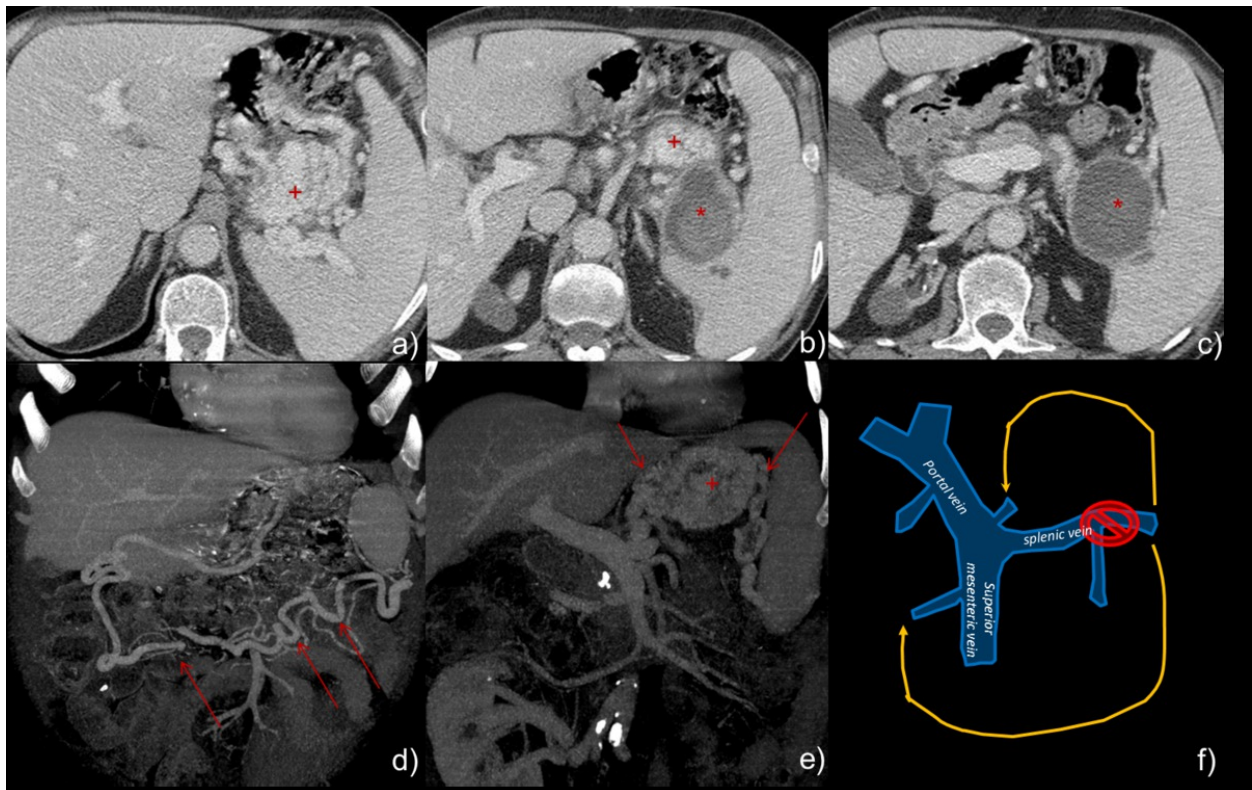


Fig. 2: Enhanced axial CT in portal venous phase images a), b) c) of a 63 year old patient with anaemia and previous renal transplantation demonstrating important signs of hypertensive gastropathy (+) with a haemorrhagic pseudocyst at the pancreas tail (*), splenomegaly with splenic vein occlusion and consequent collateralization by the gastroepiploic veins inferiorly and by short gastric and left gastric vein superiorly (arrows), better shown with the thick coronal MIP images in d) and e). In f) a schematic representation of left sided portal hypertension is shown, consisting in the presence

of digestive haemorrhage and splenomegaly with normal hepatic laboratorial values, usually due to splenic vein occlusion.

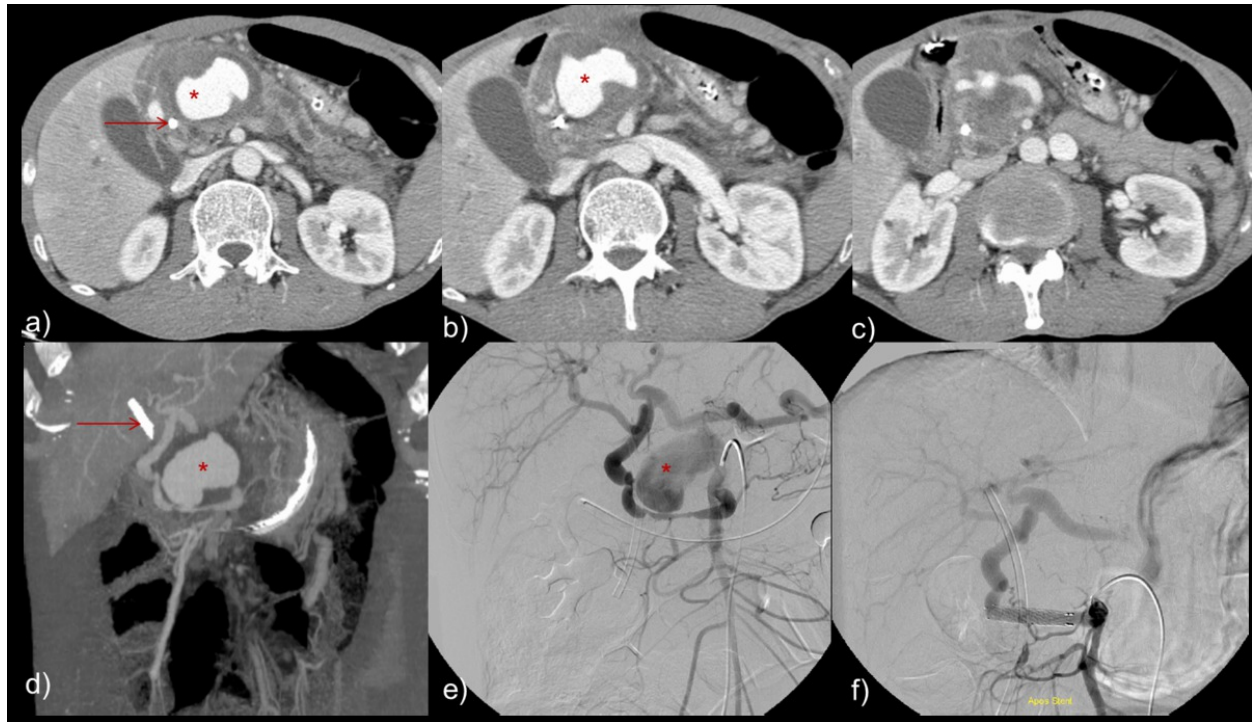


Fig. 3: Enhanced axial CT arterial phase images a), b) c) of a 53 year old male patient with severe chronic pancreatitis with a plastic biliary stent (arrows) and a large gastroduodenal pseudoaneurysm (*). Thick coronal MIP image d) demonstrated a narrow neck and a covered stent was deployed via the pancreatico-duodenal inferior artery with successful exclusion of the aneurysm e) and f).

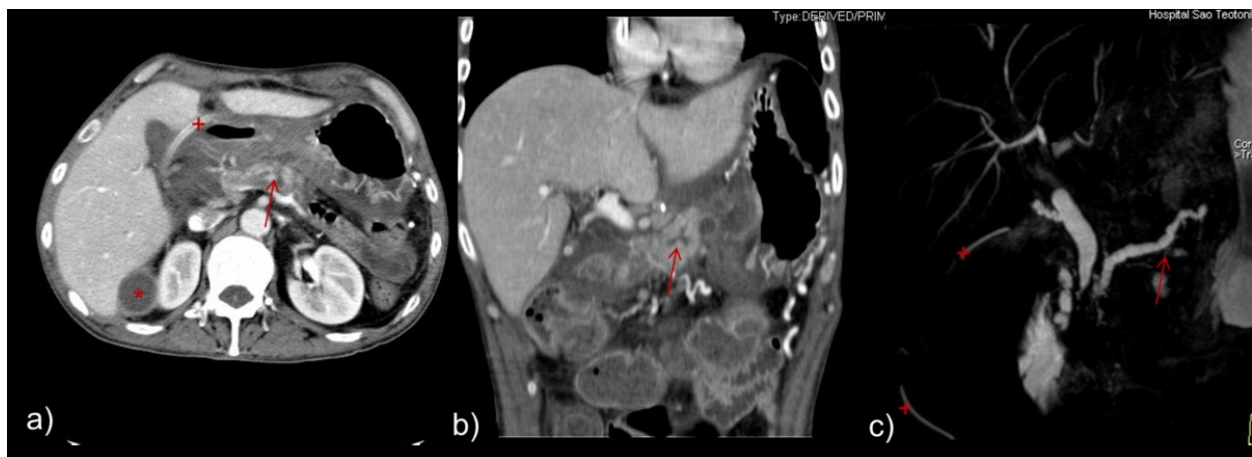


Fig. 4: axial and coronal enhanced CT images a) b) and coronal oblique MIP MRCP image c) of a patient with ascites and history of pancreatitis in whom a focal discontinuity of the main pancreatic duct was observed at the pancreatic body (arrows) corresponding

to a fistula. In the image an external drain (+) a collection posterior to the right lobe of the liver (*) can be appreciated.

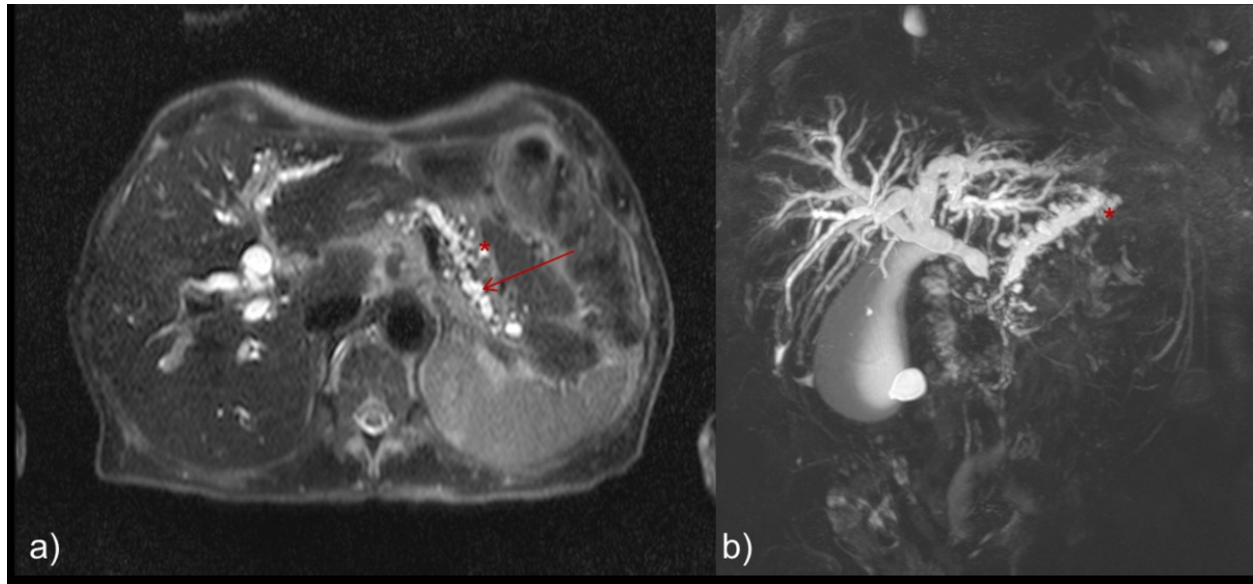


Fig. 5: Axial T2-weighted image FSE with fat saturation a) and coronal thick-slab MRCP image b), in a patient with severe chronic pancreatitis demonstrating irregular main pancreatic dilatation and dilatation of several side branch ducts (*), with parenchymal atrophy . Bile duct dilatation is also seen. This patient also had computed tomography examinations, whose findings were suggestive of chronic pancreatitis.

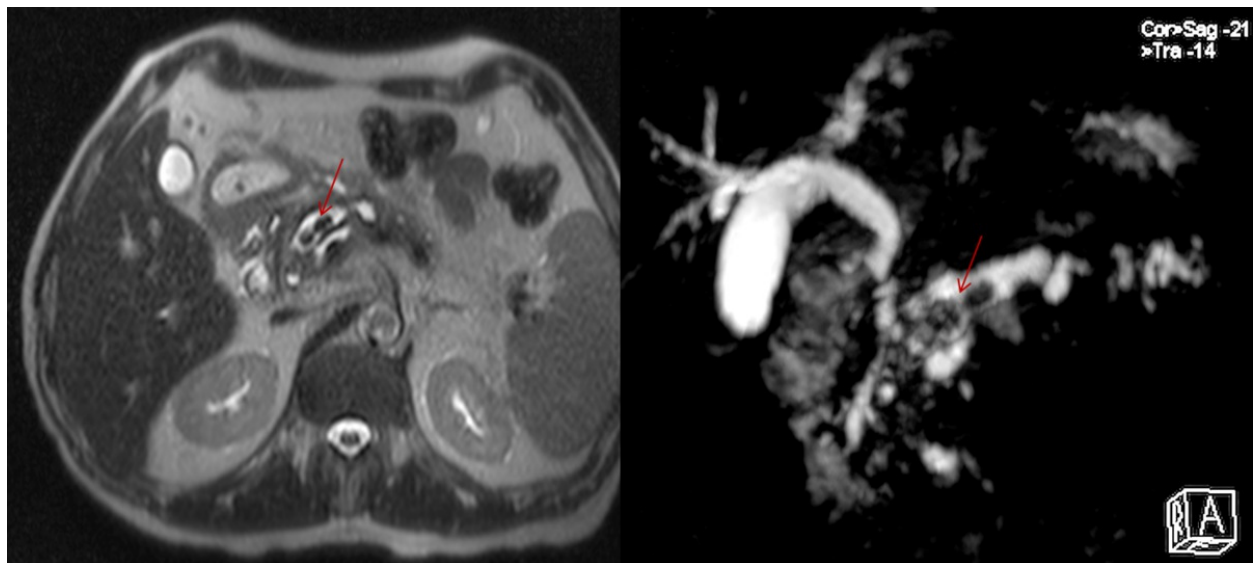


Fig. 6: Axial HASTE image a) and coronal oblique MIP MRCP image b) demonstrating irregular main pancreatic duct dilatation with two intraluminal calcifications (arrows).

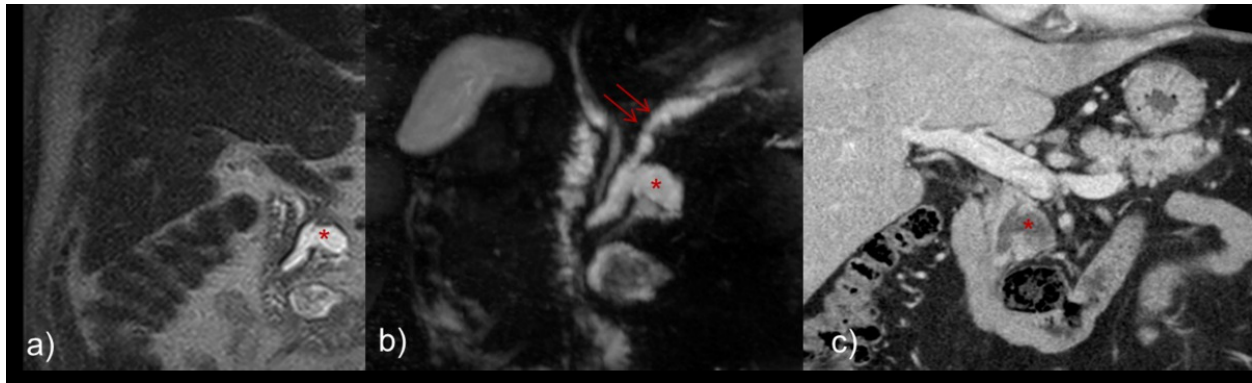


Fig. 7: Coronal HASTE image a), coronal thick MRCP projection b) and enhanced coronal CT portal venous phase image c) of a patient with main pancreatic duct strictures and irregular dilatation with a pseudocyst in the pancreatic head communicating with the main pancreatic duct.

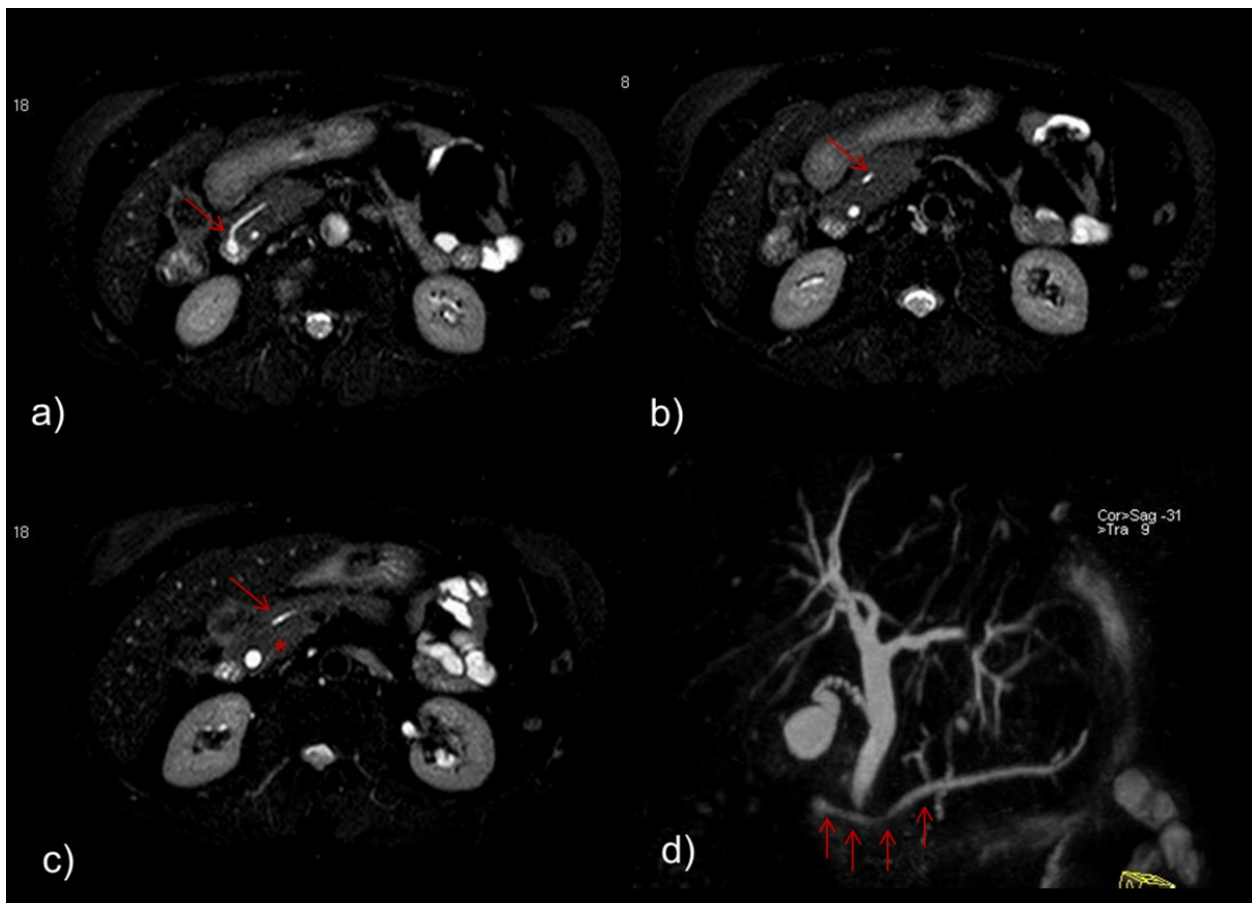


Fig. 8: Axial T2 FSE fat-suppression images a) b) c) and coronal oblique MIP MRCP image d) demonstrating the main pancreatic duct is in continuity with the duct of Santorini emptying through the minor papilla to the duodenum (arrow). Also a small ventral duct is seen in image c) (*).

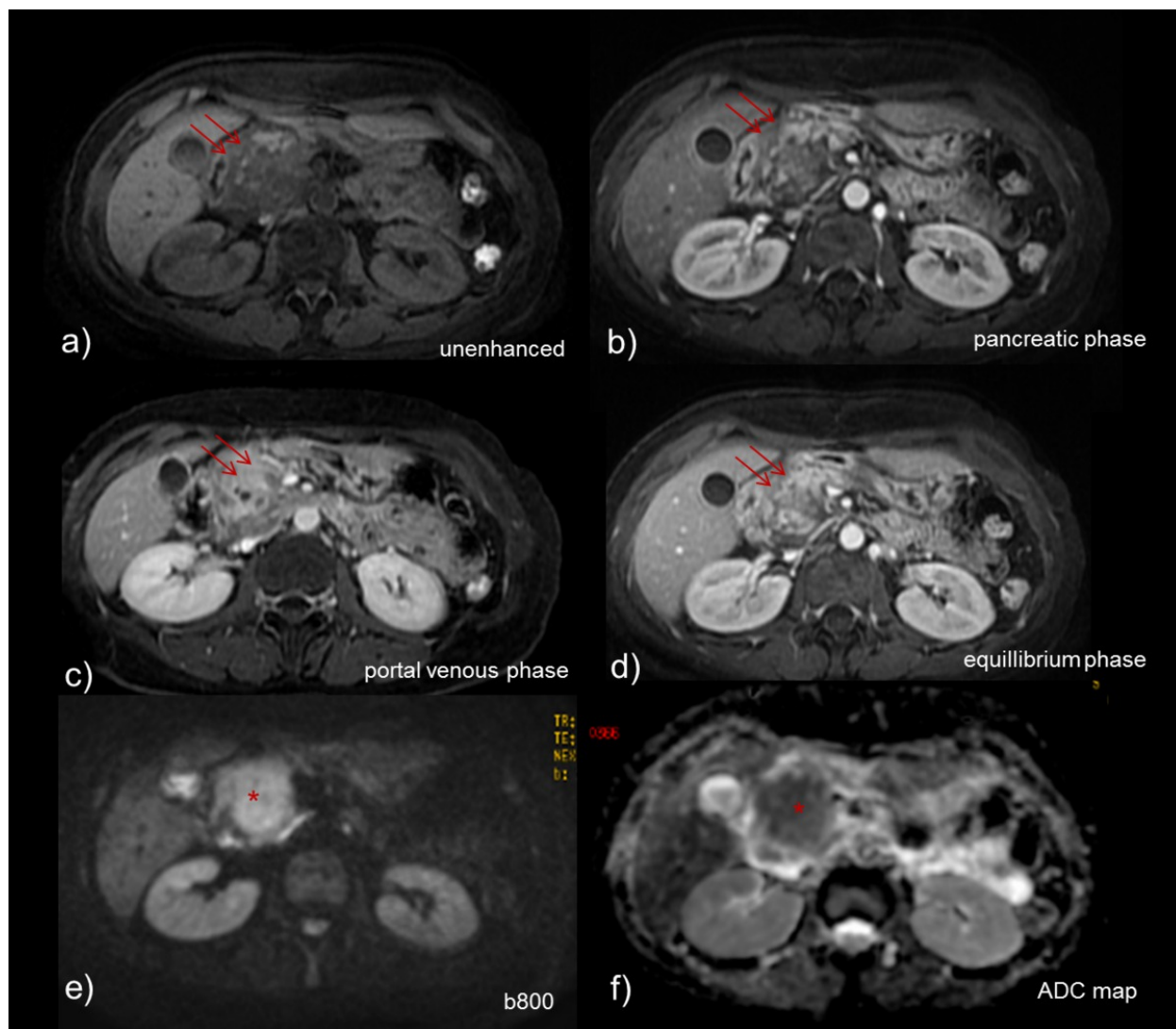


Fig. 9: Axial T1 3D fat-saturation images a) b) c) d) , axial DWI b-800 image e), ADC map f) of a patient with a hypointense mass at the pancreatic head (arrows), enhancing only in portal venous phase favoring inflammatory origin (usually adenocarcinomas enhance typically in more late phases). The lesion demonstrated restricted diffusion with low ADC values (*), however diffusion-weighted imaging doesn't allow differentiation between malignant and inflammatory masses.

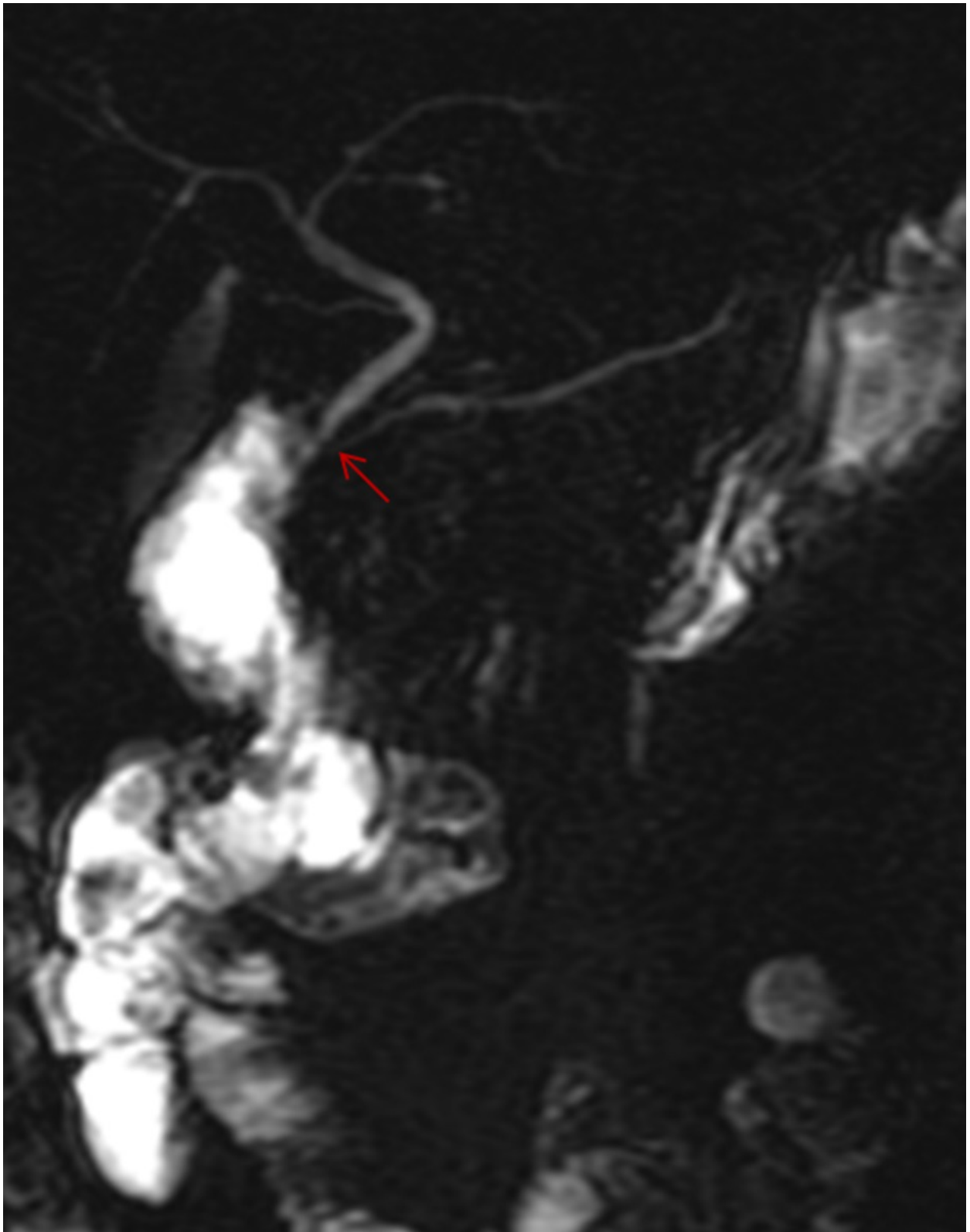


Fig. 10: Coronal oblique thick slab MRCP projection of the same patient in figure 8, disclosing regular narrowing of the main pancreatic duct at the pancreatic head - duct

penetrating sign (arrow) - finding that suggest inflammatory origin. This patient performed endoscopy ultrasound with biopsy and the results confirmed focal pancreatitis.

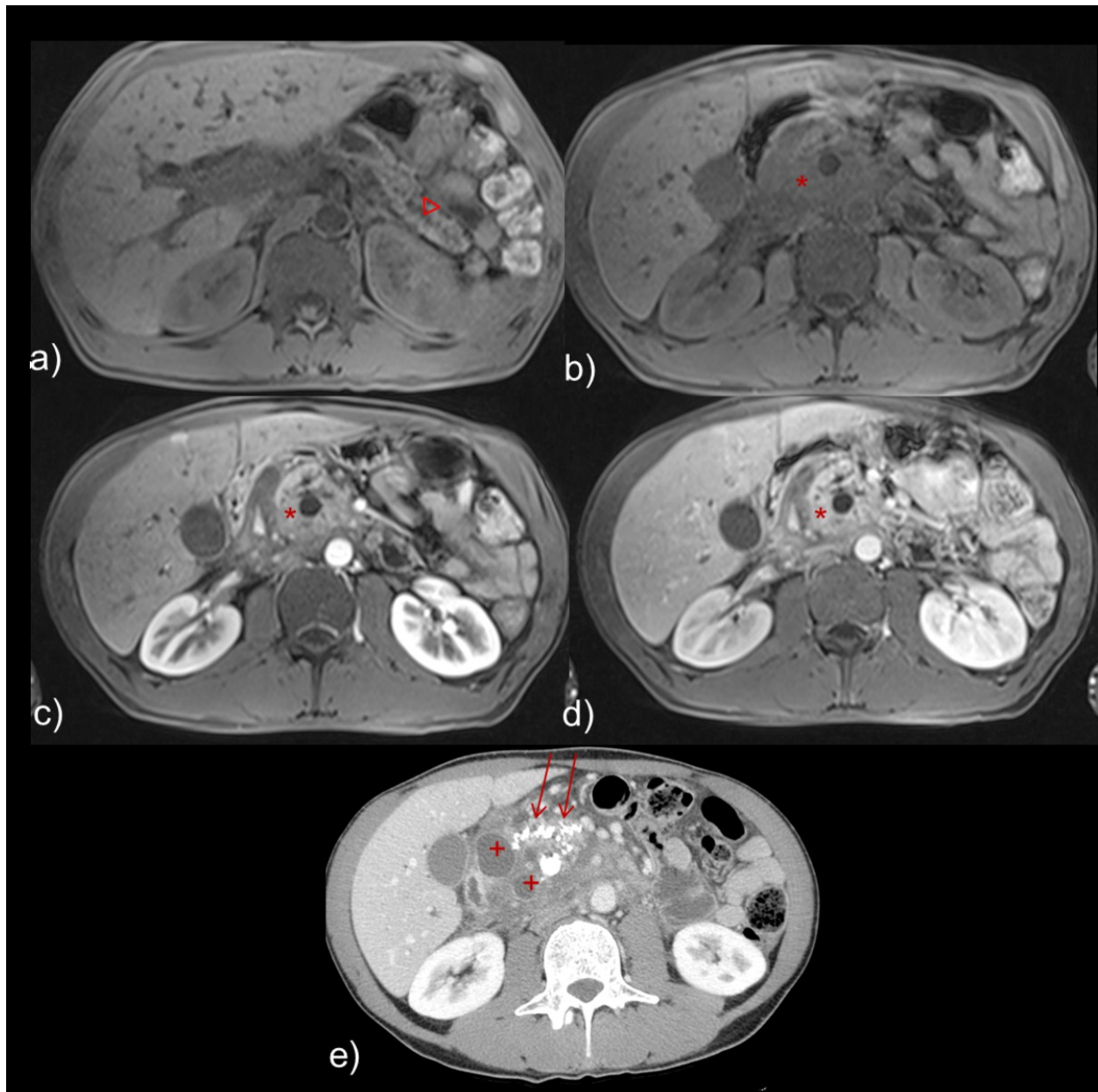


Fig. 11: Axial T1 3D fat saturation non-enhanced images a) b), axial T1 3D fat saturation enhanced images c) d), enhanced axial CT image in portal venous phase e) - Another patient with an irregular main pancreatic duct dilatation (arrowhead) and a hypointense mass at the pancreatic head and isthmus (*), enhancing progressively, also diffusion weighted imaging disclosed restricted diffusion with low ADC (not shown). At CT examination the patient presented several parenchymal and intraductal pancreatic calcifications (arrow) and also pseudocysts (+), findings favoring chronic pancreatitis.

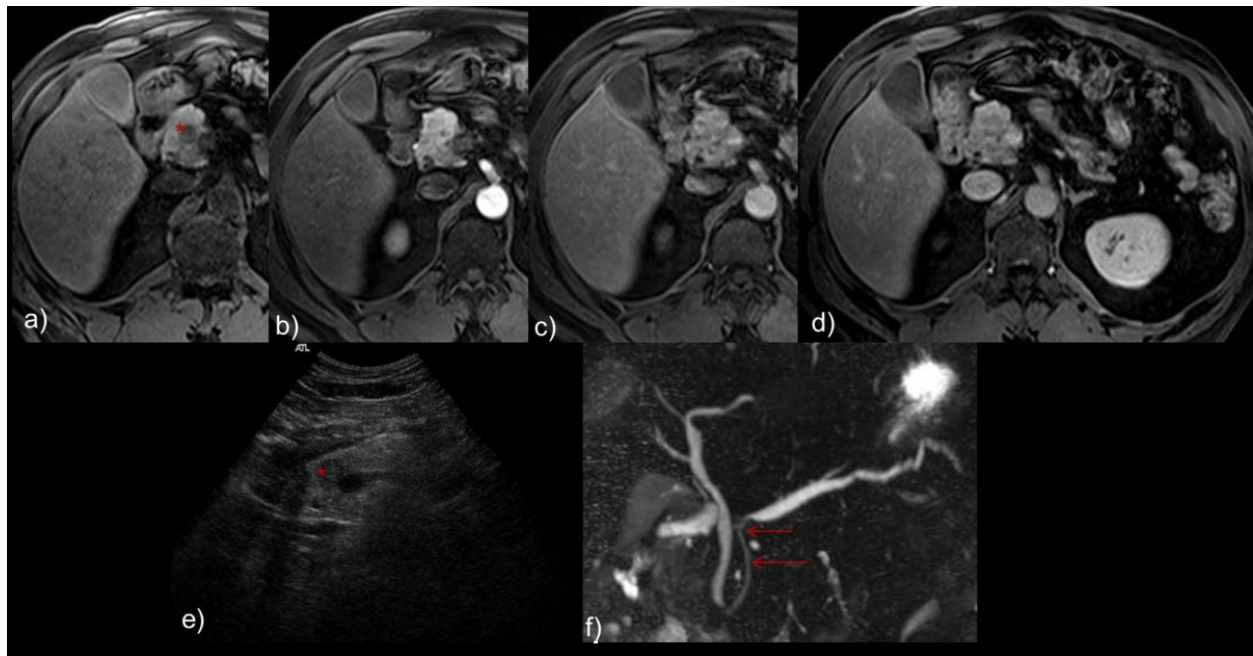


Fig. 12: Axial T1 3D fat-saturation images a) b) c) d), transversal ultrasound image e), coronal oblique thick slab MRCP image f) - Patient with a hypoechogenic peri-centimetric nodule at the pancreatic head. This nodule was not observed at CT and in MR the nodule was hypointense in T1 enhancing similarly to the remaining pancreatic head, with absence of clear demarcation between the focal nodule and the parenchyma. DWI (not shown) demonstrated restricted diffusion. At MRCP a regular and smooth narrowing of the main pancreatic duct at the pancreatic duct - duct penetrating sign (arrows) is seen suggesting the diagnosis of focal pancreatitis.

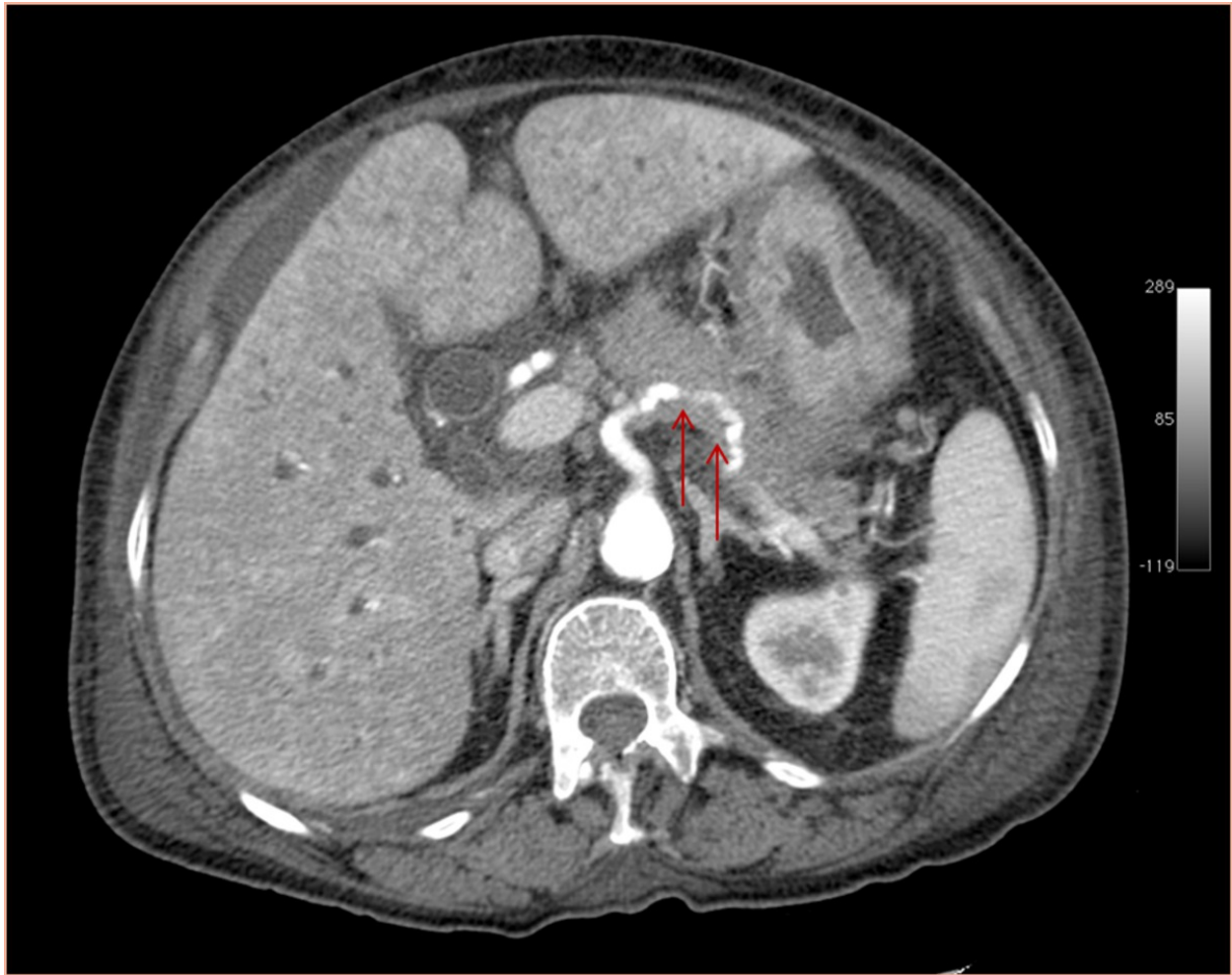


Fig. 13: Enhanced axial CT image in pancreatic phase of a patient with a hypodense mass in pancreatic body, with pancreatic tail atrophy and signs of vascular encasement of the splenic artery (arrows).

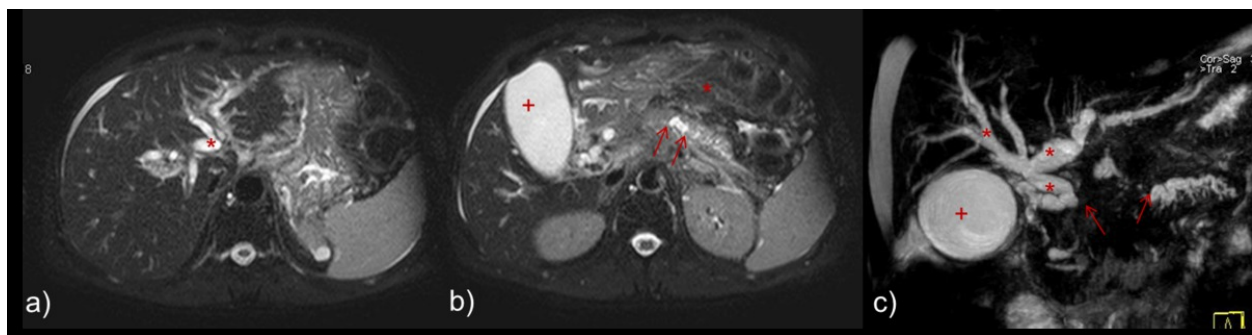


Fig. 14: Axial T2 FSE with fat suppression images a) b) and coronal oblique MIP MRCP image of a patient with bile duct dilatation (*), a distended gallbladder (+) as well as main pancreatic duct dilatation, an abrupt "cut-off" (arrows) at the pancreatic body with distal pancreatic parenchymal atrophy. Further investigation revealed pancreatic adenocarcinoma. Perihepatic ascites is also seen in this image.

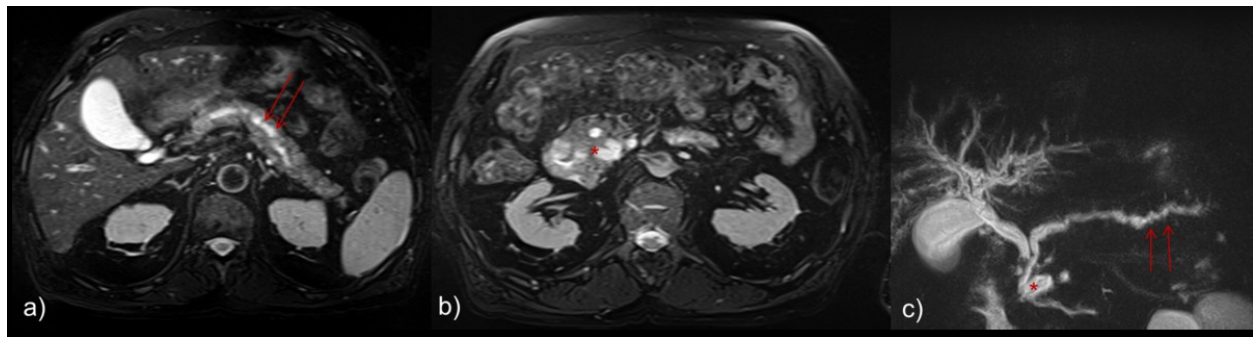


Fig. 15: Axial T2 FSE fat saturation images a) b) and coronal oblique thick MRCP image c) of an 81 year-old patient with irregular main pancreatic duct dilatation (arrows) with slight pancreatic parenchymal atrophy, presenting a cystic lesion at the pancreatic head communicating with the main pancreatic duct. This patient also presented stones at the distal main biliary duct.



Fig. 16: Axial a), coronal b) and sagittal c) enhanced images of a patient presenting with a complex cystic masse with pseudoseptations and subtle enhancing solid component (arrows). Pathological analysis confirmed the IPMN nature.

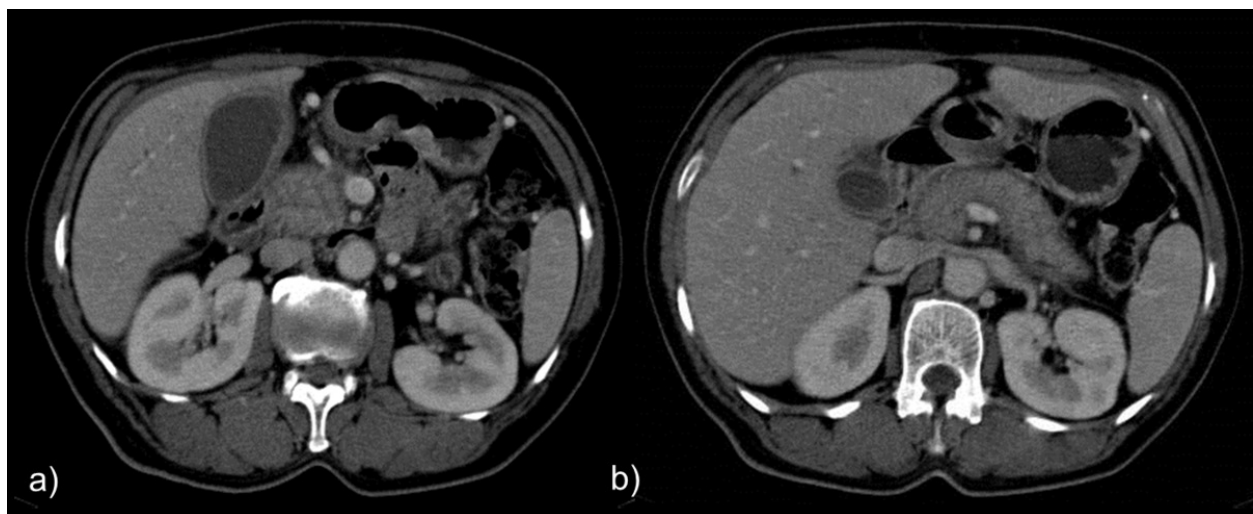


Fig. 17: Enhanced axial CT images in portal venous phase of a patient with slight diffuse enlargement of pancreas, with diffuse less enhancement and loss of normal fatty lobulation. A slight atrophy of the pancreatic tail can be seen as well as a low-attenuation halo surrounding pancreas.



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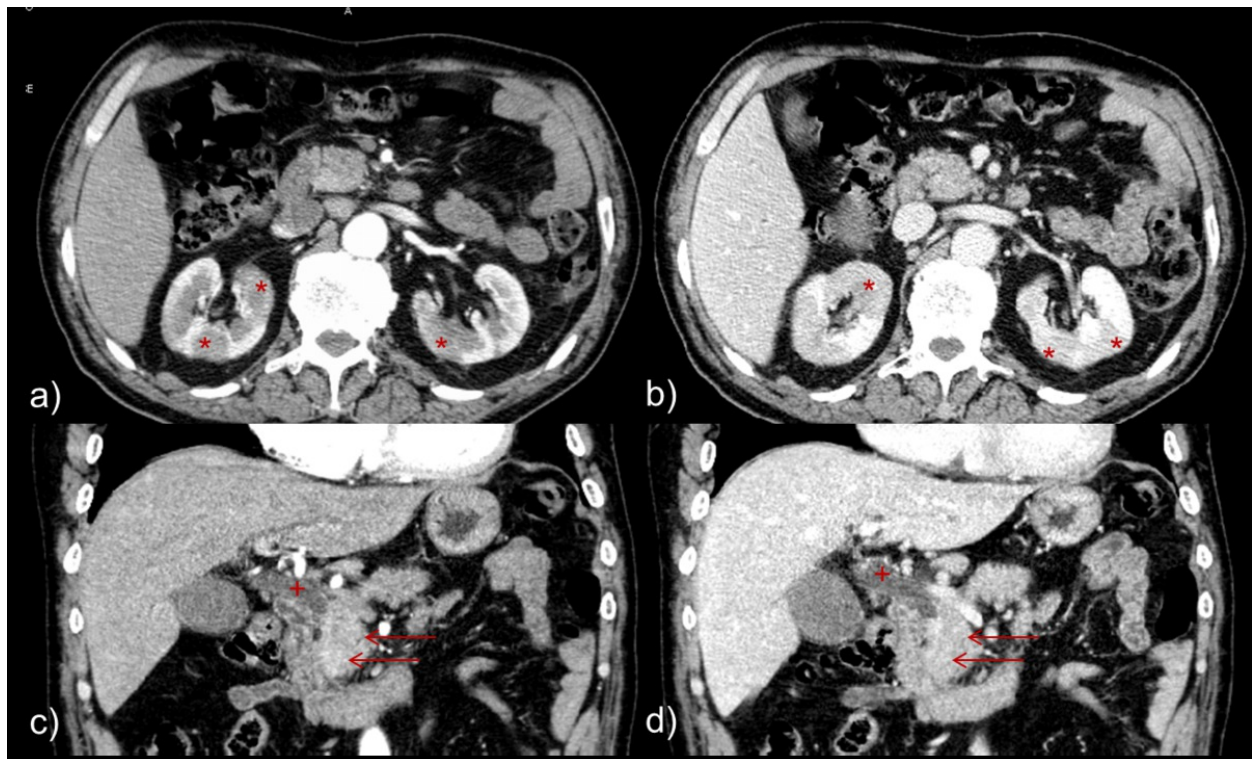


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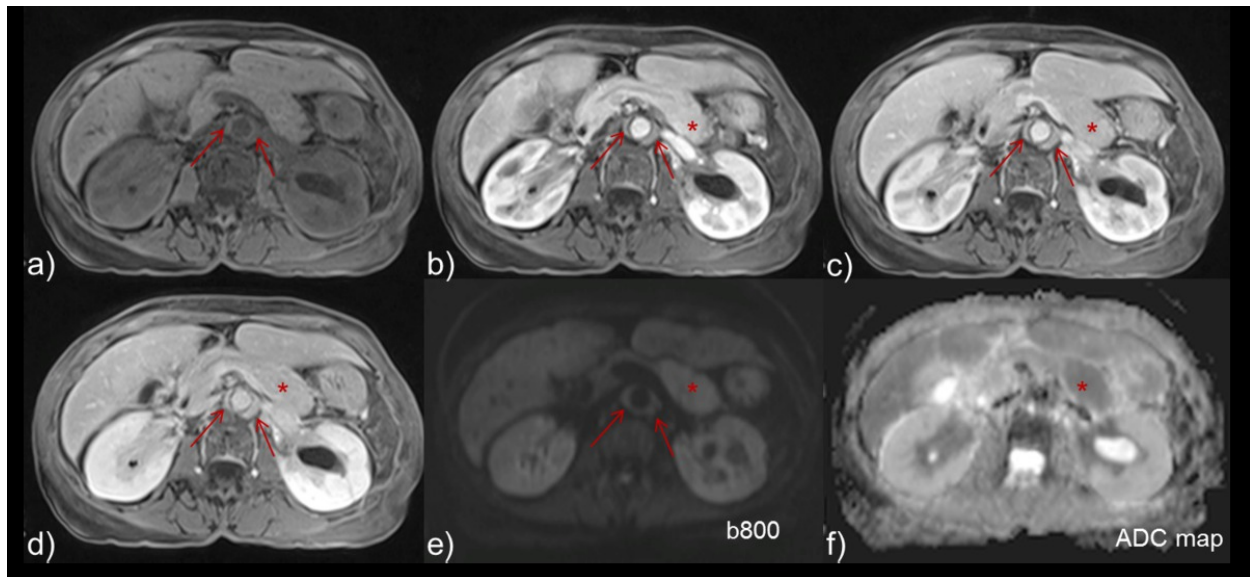


Fig. 20: Axial T1 3D fat-saturation images a) b) c) d) axial DWI b-800 image e) and ADC map f) of a patient with focal enlargement in the pancreatic tail that was isointense and enhancing similarly with the remaining parenchyma, presenting with restricted diffusion and low ADC (*). A soft tissue lesion around the aorta was also seen with similar features to the pancreatic lesion (arrows); furthermore the left kidney presented dilatation of the cavities, and the soft-tissue lesion corresponded to retroperitoneal fibrosis, seen in about 10-20% of patients with autoimmune pancreatitis.

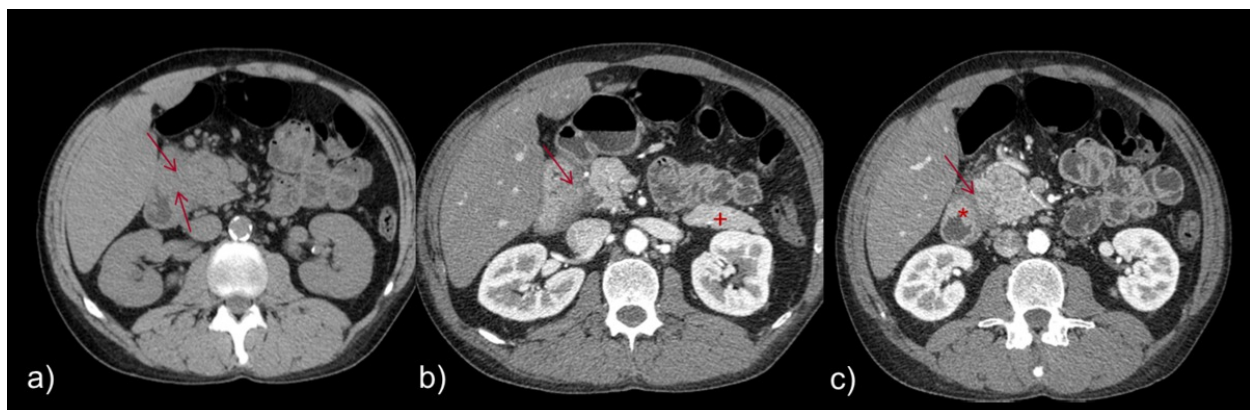


Fig. 21: Unenhanced a) and enhanced axial CT images b) c) of a patient presenting with an ill-defined "sheet-like" soft-tissue mass within the pancreaticoduodenal groove, hypointense to the pancreatic parenchyma after iodinated contrast medium administration (arrows). There is not parenchymal atrophy or main pancreatic duct dilatation (+) and thickening of the duodenal wall can be observed (*).

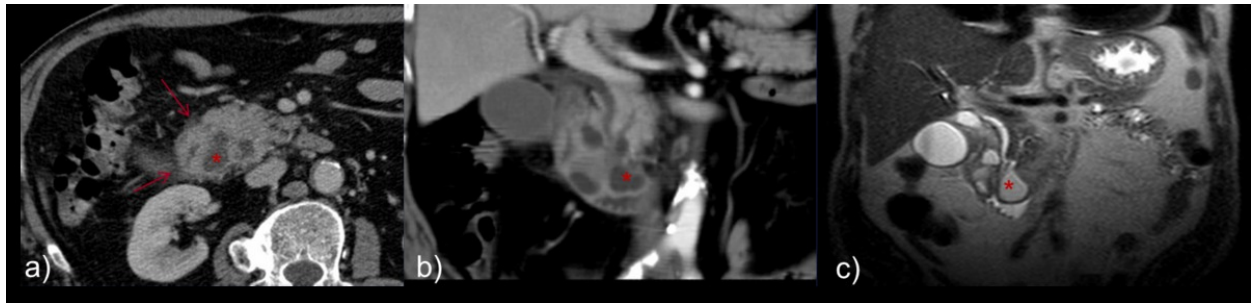


Fig. 22: Axial a), coronal b) enhanced CT images and coronal HASTE image c) of a patient with groove pancreatitis presenting with slight duodenal wall thickening (arrows) with discrete luminal stenosis and cystic changes of the duodenal wall (*).



Fig. 23: Enhanced axial a), coronal b) and thick-slab MRCP image c) of a patient with groove pancreatitis presenting a large hypodense mass at the pancreatic head with cystic areas (*) without vascular invasion and with smooth narrowing of the distal common bile and main pancreatic duct (arrow).

1) Typical imaging	Diffuse or segmental narrowing of the pancreatic duct with irregular wall and diffuse or localized enlargement of pancreas on US, CT and MR imaging
2) Serology	Autoantibodies (antinuclear antibodies and rheumatoid factor), elevated γ -globulins, or IgG or IgG4
3) Histopathology	Marked intralobular fibrosis and prominent infiltration of lymphocytes and plasma cells in the periductal area, occasionally with lymphoid follicles in the pancreas
Diagnosis is established when criteria 1 with criteria 2 or 3 are present	

Table 4: Table 4 - Japanese society of pancreas criteria for autoimmune pancreatitis

	Chronic pancreatitis	Pancreatic adenocarcinoma
History	+++	-
Duct contour	Irregular	Smooth
Duct/parenchyma	<0.5	>0.5
Calcification	+++	-
Enhancement	Diffusely decreased / preserved	Focal decrease
Cysts	+++	+ (if cystic degeneration)
Lymph nodes	+	++ (suspicious)
Metastases	-	++++

Table 3: differential criteria between CP and pancreatic adenocarcinoma - table from Helmberger TK (2011) Pancreas - parenchymal disease. In: Gourtsoyannis NC, (ed) Clinical MRI of the abdomen. Springer, Berlin, pp 225-255

Conclusion

Differentiation between focal CP and adenocarcinoma on imaging criteria remains a complex and difficult challenge; however some aspects may help in this distinction. In this respect imaging is used not only for the diagnosis, but also to investigate anatomic or pathologic causes of chronic pancreatitis, assess his severity and involvement of other organs.

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